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A SERIES OF TEXTBOOKS FOR PERSONS ENGAGED IN ENGINEERING PROFESSIONS, TRADES, AND VOCATIONAL OCCUPATIONS OR FOR THOSE WHO DESIRE INFORMATION CONCERNING THEM. FULLY ILLUSTRATED

TRANSMISSION AND CONTROL MECHANISM
BEARINGS AND LUBRICATION
AUTOMOBILE-CHASSIS LUBRICATION
AUTOMOBILE-ENGINE LUBRICATION
AUTOMOBILE TIRES
VULCANIZATION OF AUTOMOBILE TIRES

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PREFACE

The volumes of the International Library of Technology are made up of Instruction Papers, or Sections, comprising the various courses of instruction for students of the International Correspondence Schools. The original manuscripts are prepared by persons thoroughly qualified both technically and by experience to write with authority, and in many cases they are regularly employed elsewhere in practical work as experts. The manuscripts are then carefully edited to make them suitable for correspondence instruction. The Instruction Papers are written clearly and in the simplest language possible, so as to make them readily understood by all students. Necessary technical expressions are clearly explained when introduced.

The great majority of our students wish to prepare themselves for advancement in their vocations or to qualify for more congenial occupations. Usually they are employed and able to devote only a few hours a day to study. Therefore every effort must be made to give them practical and accurate information in clear and concise form and to make this information include all of the essentials but none of the non-essentials. To make the text clear, illustrations are used freely. These illustrations are especially made by our own Illustrating Department in order to adapt them fully to the requirements of the text.

In the table of contents that immediately follows are given the titles of the Sections included in this volume, and under each title are listed the main topics discussed.

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CONTENTS

NOTE.—This volume is made up of a number of separate Sections, the page numbers of which usually begin with 1. To enable the reader to distinguish between the different Sections, each one is designated by a number preceded by a Section mark (§), which appears at the top of each page, opposite the page number. In this list of contents, the Section number is given following the title of the Section, and under each title appears a full synopsis of the subjects treated. This table of contents will enable the reader to find readily any topic covered.

AUTOMOBILE TIRES—(*Continued*)

§ 14

VULCANIZATION OF AUTOMOBILE TIRES, § 15

TRANSMISSION AND CONTROL MECHANISM
(PART 1)

FRICTION CLUTCHES

CONSTRUCTION

PURPOSE OF A CLUTCH

1. In an automobile driven by an internal-combustion engine, means must be provided for connecting the engine to the transmission gearing or disconnecting it from this gearing, either while the gears are being shifted or when the car is to be stopped with the engine running. This is necessary in the first case, because with the ordinary form of transmission, or speed-changing gears, the engine must be disconnected from the gearing while the speed is being changed in order to make a smooth and noiseless shift and to avoid injury to the mechanism. In the second case, it is necessary when it is desired to stop the car for a short time without stopping the engine, or when the car must be stopped suddenly, as in an emergency. For the purpose named, a **friction clutch** of some suitable form is employed in nearly all cars. The clutch forms part of the engine in most cars, but in some old cars it was incorporated in the same housing with the gears by which the speed of travel of the car is regulated. Cars containing a so-called friction transmission do not need a clutch, as its function is performed by separating the different members of such a transmission. While a number of different cars containing a fric-

tion transmission were formerly built, this form of a transmission is rarely found at present.

2. Some of the most important qualifications that the friction clutch must fulfil in order to give satisfactory operation in automobile service are as follows:

1. It should engage without seizing and thereby jerking the car.
2. It should hold without slipping after the car has been started and the clutch is in full engagement, except under very unusual conditions in which the speed of rotation of the road wheels is very suddenly checked.
3. It should release instantly, without dragging the driven parts around, as soon as the disengaging mechanism is operated.
4. It should be of such form that the driven side will have a minimum tendency to keep rotating by its own momentum after the clutch is released. In other words, the flywheel action of the part of the clutch that is connected to the power-transmitting mechanism should be as small as possible.
5. It should not require constant adjustment and attention to keep it operating properly.
6. All parts should be of proper strength and possess lasting qualities.

3. The friction clutches used in automobiles are of several general types, depending on the manner in which the required friction is produced. These types, or classes, are the *cone clutch, disk clutch, expanding clutch,* and *contracting clutch.* In each case, however, an adequate device must be employed for bringing the members of the clutch in contact.

In the **cone clutch,** the necessary friction is produced by forcing two cone-shaped members together, one within the other, so that the conical surfaces come into contact. One member of the clutch is driven by the engine while the other member is attached to the propeller shaft or transmission shaft.

The **disk clutch** makes use of a number of plates, or disks, that are forced together. One set of disks is attached to the

engine shaft and the other set connects to the propeller shaft or transmission shaft. The disks form a sufficiently large contact surface to produce the required friction.

When disk clutches have a large number of disks, they are usually spoken of as *multiple-disk clutches,* but when they have only a few disks, large in diameter, they are often referred to as *plate clutches.* There is no sharp line of demarcation between multiple-disk and plate clutches.

In the **expanding clutch,** two cylindrical members are used, one within the other. The diameter of the inner member can be increased, thus forcing it outwards against the outer part and causing the desired friction.

The **contracting clutch** differs from the expanding clutch only in that the outer member is of variable diameter, which may be decreased. The outer member can thus be tightened about the inner one and the required friction produced.

While expanding as well as contracting clutches were at one time quite popular with makers of high-priced cars, they are not employed in present day practice, although encountered on many of the older cars still in service.

In standard present day practice the driving and driven members of the clutch are normally in full engagement, being firmly pressed together by one or more steel springs. Disengagement of the clutch from the speed change-gear mechanism is brought about by pressing the clutch pedal forward, which through some suitable mechanism withdraws the driven clutch member from the driving clutch member, compressing thereby the clutch closing spring or springs. From this it follows that the engine is disconnected from the transmission as long as the clutch pedal is held depressed by the foot of the operator; as soon as the foot pressure on the pedal is released, the clutch closing spring or springs at once presses the driving and driven clutch members together, thereby *engaging* the clutch, as it is called, and thus connecting the engine to the transmission. Therefore, if the engine is to run idly without the operator holding the clutch disengaged, the transmission must be placed in neutral, that is, in a position where no power can be transmitted through it.

4. The cone clutch and the disk clutch have each their own advantages and disadvantages, but in neither case are the advantages of either type so marked as to have led to its universal adoption to the practical exclusion of the other.

The advantages of the cone clutch are its extreme simplicity, low first cost, and ease of repair of the friction member subject to wear, with material obtainable almost anywhere; the greatest disadvantages are that the necessity for heavy closing springs involves considerable effort on the part of the operator to release the clutch, and that skill is needed to handle it without causing shocks on the car mechanism. The advantages of the disk clutch, and especially of the type having a large number of disks, are that the light closing spring or springs required involve a very small effort to disengage the clutch, that it does not require quite so skilful handling as a cone clutch in engaging, and that it withstands abuse to a greater degree than a cone clutch. Its disadvantages are its high first cost, high cost of repair, difficulty of repair, as special material not obtainable everywhere is needed, and, in the type in which the disks run in oil, failure to release promptly under all conditions. Yet, the increasing use of the disk clutch proves that neither manufacturers nor the buying public consider its disadvantages to be very serious.

CONE CLUTCHES

5. Classification.—The cone clutches used in connection with automobile engines may be divided into *single-spring* and *multiple-spring* clutches, according to whether a single closing spring or several such springs, are used. Such clutches may also be divided into *leather-faced* and *fabric-faced cone clutches,* depending upon what material is employed to give the required friction. Leather facing is almost universally employed in cone clutches; fabric facing made of woven asbestos, in spite of its great wear-resisting quality compared with leather, is but little used, although this material is almost exclusively employed with disk clutches.

Cone clutches, in accordance with their operation, can also be classified as *direct* and *reversed clutches.* The practically

universal form of cone clutch is the direct one, in which the movable member is drawn to the rear to release it, by pressing

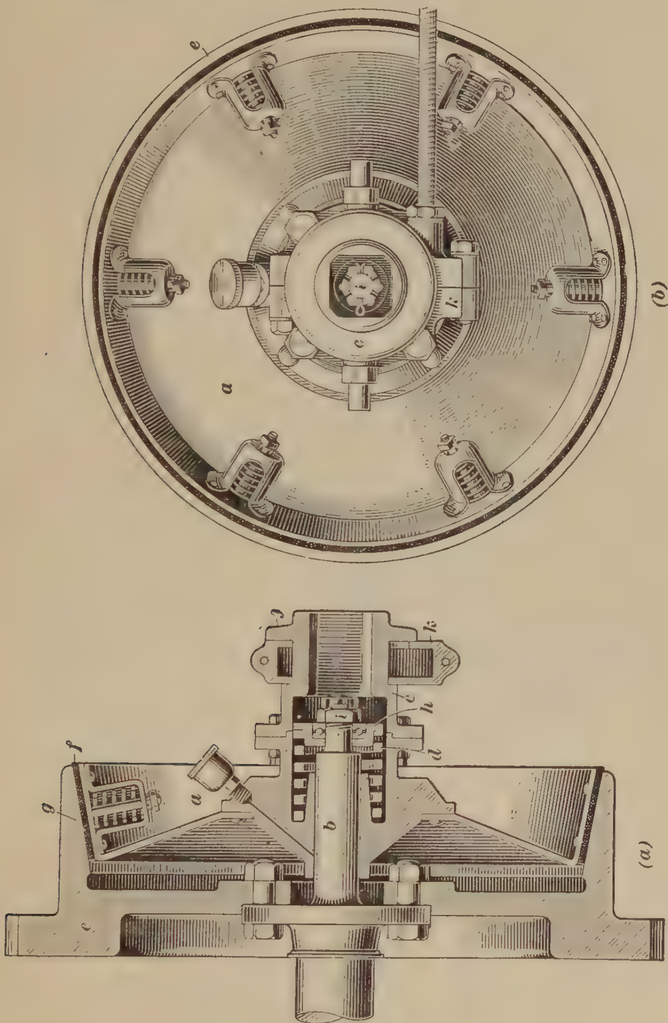


Fig. 1

the clutch pedal forwards, and moves forward to engage when the clutch pedal is released. The reversed cone clutch is but little used today; in this the movable cone is pushed forwards

to release it, by pressing the clutch pedal forwards, and moves to the rear to engage when the clutch pedal is released.

Control of all types of clutches by a clutch pedal is now universal.

6. Direct Cone Clutches.—A single-spring direct cone clutch is shown in place in the flywheel, in cross-section, in Fig. 1 (*a*), and in end view in (*b*). The same clutch, with certain members omitted, is illustrated in perspective in Fig. 2, and both illustrations should be referred to in reading the description. The internal cone *a* is free to slide lengthwise and also to rotate on the rear end *b* of the crankshaft. The particular cone clutch illustrated is used in the unit power plant of Dort cars, and a sliding connection to the transmission shaft (not shown) is made by a squared hole in the rear end of the clutch-spring casing *c*, which is bolted to the

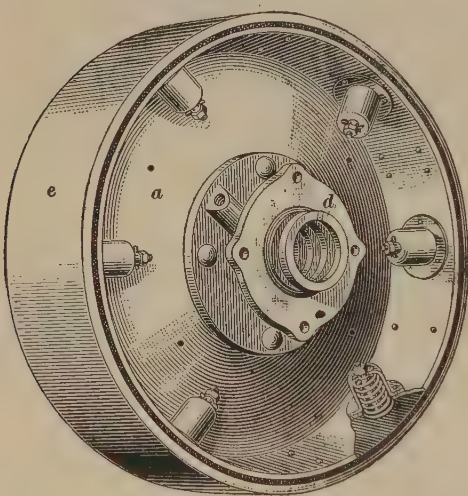


FIG. 2

hub of the internal cone *a* and encloses the clutch-closing spring *d*. The squared hole in the clutch-spring casing fits over the squared forward end of the main transmission shaft when the clutch is assembled in place; in many unit power plants the connection between the internal cone and the transmission is made by *splines*, which are keys cut from the solid material. In cases where the transmission is entirely separate from the engine, connection from the internal clutch cone either to the transmission or to the propeller shaft is made by one or two universal joints, to allow for disalinement between the engine and propeller shaft or transmission.

7. The external cone is formed in the rear of the engine flywheel *e*, Figs. 1 and 2, which always is rigidly fastened to the crankshaft of the engine; therefore, the external cone always rotates with the crankshaft. When the two clutch cones are brought together with the outside surface *f* of the inside cone in firm contact with the inside surface *g* of the outside cone, the clutch as a whole is said to be in engagement; the clutch is shown in this position in the three views presented in Figs. 1 and 2. If the outside cone is rotating, that is, if the engine is running, and the inside cone is engaged with it, the friction between the conical surfaces in contact will carry the inside cone around and thereby cause this to transmit the turning effort (the force exerted), or *torque*, of the engine to the driving wheels when the transmission gears are engaged. The force with which the inside cone is driven, of course never exceeding that due to the engine torque, depends on the pressure and the friction between the conical clutch surfaces. On account of these friction surfaces being conical, there is a wedge-like action that gives a pressure much greater than the force with which the driven, or inside, cone is pressed toward, and hence against, the driving, or outside, cone. The proper inclination of the conical friction surfaces to permit firm gripping and reasonably prompt releasing has been found by practical experience to be about as shown in Fig. 1 (*a*); the inclination to the center line averages about 12 degrees.

8. In the cone clutch shown in Figs. 1 and 2, the closing spring *d* is confined under compression between the hub of the inside cone and the clutch thrust bearing *h*, Fig. 1 (*a*), which thrust bearing is on the extension *b* of the crankshaft and is confined lengthwise by the clutch-spring adjusting nut *i*. From the construction it can be seen that, because the closing spring is under compression, it presses the inside cone forwards, that is, into the outside cone.

To disengage the clutch, the inside cone is withdrawn from the outside cone, and in doing this the clutch-closing spring must be still further compressed; in the particular design shown a collar *j*, Fig. 1, is formed on the clutch-spring casing, against

which the clutch collar *k* is pressed when the clutch pedal of the car is pushed forwards. The collar *k* is thereby forced toward the rear of the car, carrying the clutch-spring casing *c* and hence the inside cone *a* with it, thus leaving the flywheel free to rotate without driving the inside clutch member. In other words, the engine is now entirely disengaged from the transmission and hence from the car. In connection with this it should be understood that, with the transmission gears in neutral and the clutch engaged, the engine is also disconnected from the car.

9. The clutch fitted to the engine, irrespective of what type of friction clutch is employed, permits the automobile to be started gently, that is, without shock or jar, by careful manipulation. Thus, with a cone clutch, by allowing the inner cone to engage slowly with the outer one the latter slips somewhat on the inner cone, at the same time starting it to rotate and slowly increasing its speed of rotation, thereby gradually setting the car into motion. While a certain amount of this slipping of the clutch is essential to easy starting of the car, undue slipping will wear out any clutch very rapidly, and therefore speed changes of the car should in general be effected by the throttle, spark advance lever, and the transmission, slipping of the clutch being confined entirely to starting the car.

To aid in easy engagement of cone clutches, these are often fitted with special devices which are illustrated and described further on.

10. As the friction between metallic surfaces is rather low, being, broadly speaking, insufficient for cone clutches of automobiles, the inner member of a cone clutch is always lined with some material giving great friction. The material most commonly employed is leather, which is softened with neat's-foot oil and riveted in the form of a conical band to the conical part of the inner clutch member. In a few instances an asbestos-fabric clutch lining similar to regular brake lining is used; this material is not affected by heat, and therefore does not burn out like leather when the clutch is slipped excessively, gives a high friction, and wears well, but has the disadvantage

of being very stiff and therefore requires more skilful handling of the clutch than is the case with a softer facing.

11. A multiple-spring cone clutch as used in some Mitchell cars is shown in Fig. 3. In this illustration the flywheel *a*, as usual, also forms the outer, or driving, clutch member. The inner clutch member *b* is made of pressed steel and has riveted to it the leather clutch facing *c*. The two clutch members are pressed together by a number of helical springs *d*, which are carried on studs *e* firmly attached to a spider *f* free to rotate

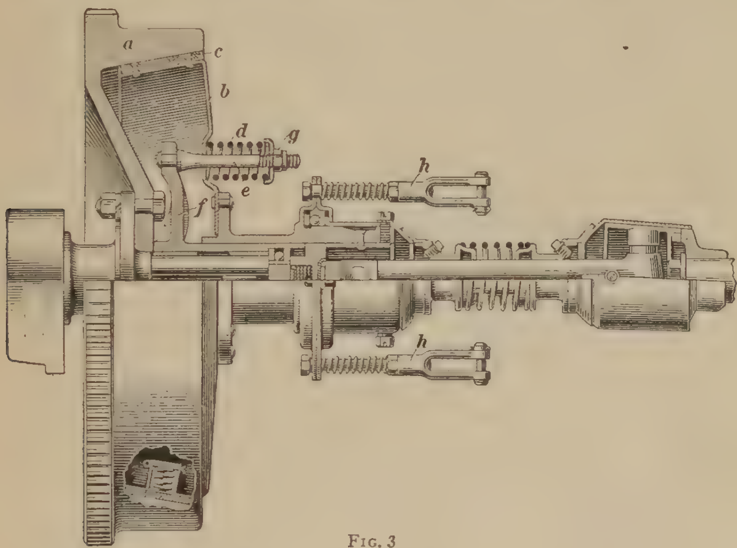


Fig. 3

in respect to the flywheel *a*. In this case the studs *e* have adjusting nuts *g* for adjusting the tension of the clutch springs *d*; in many clutches, however, the tension of the clutch springs cannot be changed. The clutch shown is released by the clutch pedal, which, when pushed forward pulls back the rods *h*, which in turn draw the inner clutch member *b* to the rear.

The number of springs used in multiple-spring cone clutches ranges from three to six in standard practice; the number actually employed depends on the personal preference of the designer.

12. Reversed Cone Clutches.—One characteristic feature of the reversed cone clutch is that the outer clutch member cannot be formed directly by the flywheel, but must be separate from this and bolted thereto in order to permit assembly of the clutch. The second characteristic feature, as previously stated, is that the inner clutch member is moved forwards to disengage the clutch, and rearwards to engage it. Reversed cone clutches are used today by very few car manufacturers.

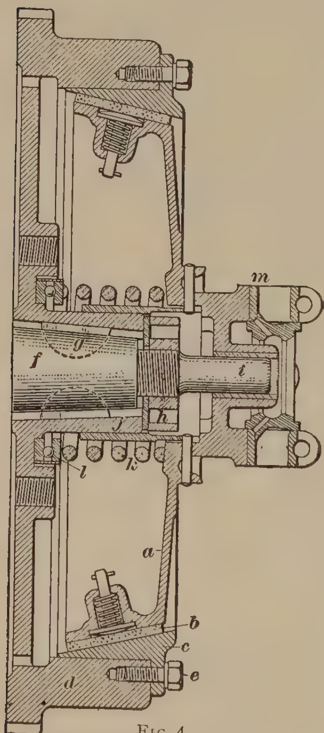


FIG. 4

An example of a reversed cone clutch is shown in Fig. 4, which is a sectional view of the clutch used in Briscoe cars. The internal cone *a* has a leather facing *b* riveted to its circumference. The external cone *c* is a separate casting bolted to the flywheel *d* by a number of bolts *e*. The flywheel, as usual, is rigidly fastened to the rear end of the crankshaft; in this case by means of a taper *f* on the end of the crankshaft, two keys *g*, and a nut *h*. The internal cone *a* runs on an extension *i* of the crankshaft, and the hub *j* of the flywheel. A single clutch spring *k* is used, which surrounds the hub of the inside cone, and bears against the ball-thrust clutch collar *l* at the front, and the hub of the inside cone at the rear. Hence, the clutch spring keeps the inside cone pressed against the outer one.

In this particular case the clutch throw-out collar, by which the clutch is disengaged when the clutch pedal is pressed forwards, is located on the propeller shaft, the forward end of which is fastened by a universal joint to a yoke *m* of the inside clutch member.

13. Methods of Securing Clutch Facing.—Practically the only method employed today for fastening either leather or asbestos-fabric clutch facing to the inner member of a cone clutch is to attach it by means of copper rivets, the heads of which are countersunk, so as to be below the surface of the facing. Two kinds of copper rivets are used; the one kind is known as a belt rivet and has a rather flat, large head, and the other kind has a rather small head resembling in general shape that of an ordinary flat wood screw, excepting there is no slot. These copper rivets are regularly manufactured in different sizes and lengths. The object of using copper rivets instead of iron ones is to prevent distortion of the inside cone in riveting; the material of the copper rivet being quite soft, very light hammer blows will form the rivet head.

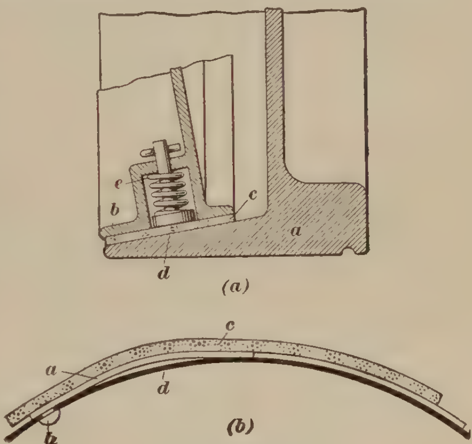


Fig. 5

While methods of fastening the friction material otherwise than by rivets, as, for instance, by bolts, have been used, the simplicity and effectiveness of riveting have caused this method to virtually supplant all others.

14. Devices for Securing Smooth Clutch Engagement.—In order to bring a cone clutch into engagement gently, various methods of causing a part of the friction surface to come first into contact with the outer cone, and then later all the friction facing into engagement, have been put into use. A common device for reducing the tendency of the clutch to seize and jerk, is shown in Fig. 5 (*a*). In this view, the external cone is shown at *a*, a part of the metal of the internal cone at *b*, and the leather facing at *c*. A plunger *d*

is set into the metal of the cone and is forced out by an expansion spring *e* against the inner side of the leather, its outward motion being limited by a cotter pin in the stem of the plunger. This presses out the part of the leather that is over the end of the plunger, so that it stands higher than the other parts of the leather facing. Several of these plungers are used in the complete cone. When such a clutch is brought into engagement, the high portions of the leather facing first come into contact with the external cone; thus, the pressure against the leather is limited to the expansive force of the springs *e*. The clutch, therefore, does not grip suddenly and jerk.

Instances of this method of securing a soft clutch action, which is the most commonly used, can be seen in Figs. 1, 2, 3, and 4.

15. In Fig. 5 (*b*) is shown a side view of a flat spring, which occasionally is used for securing a gentle engagement between the clutch members. The spring *a* is usually secured to the cone by a single rivet *b* and is slightly bent as shown. As the clutch is engaged, the spring becomes flattened, thus allowing the members to come together gradually. The clutch leather is shown at *c* and the pressed steel cone at *d*.

In some cases flat springs are placed lengthwise of the internal cone, set into recesses formed on its circumference.

16. A gentle engagement of the members of a cone clutch has sometimes been secured by cutting holes through the friction facing and inserting pieces of cork whose outer ends project slightly above the face of the leather. The cork, if of good quality, is easily compressed, so that it has about the same action as the facing forced out by a plunger. Cone clutches fitted as just described are known as *cork-insert clutches*, but are found at present only on old cars.

17. In some Marmon cars, which use a cone clutch with asbestos-fabric friction facing, the plungers are not placed on the inside cone, but on the outside cone; and they project about $\frac{1}{16}$ inch from the inner face of the outer cone. These plungers gradually recede into their sockets as the clutch is permitted to engage. The woven asbestos-fabric clutch facing

is so stiff compared with leather that it is not feasible to place plungers beneath this kind of facing.

A very satisfactory clutch action with an asbestos fabric faced cone clutch is secured by running the clutch in oil; this is done in some Maxwell cars.

18. Clutch Brakes.—A device occasionally used in connection with cone as well as disk clutches, and applied to the inside member when this is released, is known as a *clutch brake*. Its purpose is to decrease rapidly the speed of the inside member when the clutch is disengaged and the transmission gears are unmeshed, for shifting from a lower to a higher gear, in order to promote a quiet gear shift. The manner in which the clutch brake acts upon the transmission gears, and the conditions under which the clutch brake is used, will be fully explained in its proper place.

Clutch brakes may be constructed in many different ways; broadly speaking, a clutch brake is some kind of a friction device pressed against the inside clutch member only when the latter is released from the outer one, the resultant friction slowing down the inside clutch member, which after release keeps on spinning for a little while under its own inertia.

19. Probably the simplest form of a clutch brake that is in actual use consists simply of a large leather washer placed against the forward end of the transmission housing; upon disengaging the clutch the hub of the inside clutch member is pushed against this leather washer, the resultant friction slowing this clutch member down. The objection to this extremely simple form of clutch brake is that it requires considerable skill to operate it properly, as by pressing the clutch pedal forward too hard the clutch brake slows the inner clutch member down faster than required.

20. In some Studebaker cars a yielding clutch brake, the action of which is largely independent of the skill of the driver, is used; this is shown in top view in Fig. 6. A disk *a*, shown in cross-section, is fastened to the inside clutch member *b*. When the clutch pedal is depressed far enough, this member *b* is drawn sufficiently to the rear to have the disk *a* bear against

the clutch brake facing *c* of the two clutch brake arms *d* which are hinged to two frame members of the car at *e*. These clutch brake arms *d* are set out by brake arm springs *f*, and consequently can yield by compressing these springs. An adjusting screw *g* with a locknut *h* is provided for each brake arm for regulating the gap between the clutch brake disk *a* and the

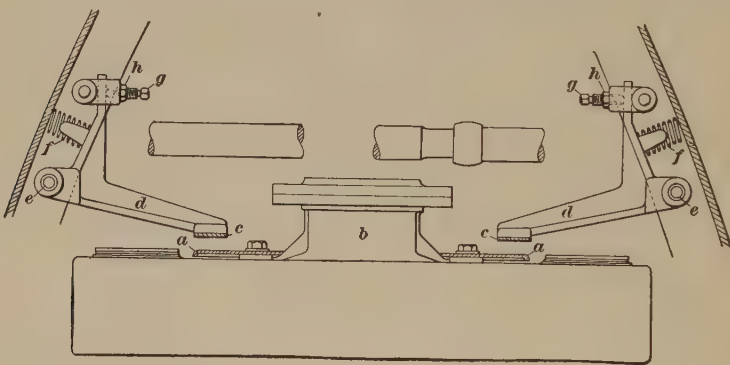


FIG. 6

clutch brake facing *c*, so that both sides may touch at the same time; in the design shown the gap, with the clutch engaged, is made $\frac{5}{16}$ inch.

From the construction it will be plain that the clutch brake action is under the control of the operator, depending upon the distance the operator presses the clutch pedal forward. That is, by pressing the clutch pedal just enough to release the clutch, the clutch brake remains out of action; by pressing the clutch pedal farther forwards, the clutch brake is brought into engagement, slowing the rotating and now released inside clutch member.

DISK CLUTCHES

21. Principle of Disk Clutch.—In Fig. 7 is shown a simple form of **disk clutch,** which illustrates the principle on which clutches of this type operate. It consists of a driving shaft *a* and a driven shaft *b*, to which power is transmitted by the friction disks *c* and *d* when their flat adjacent surfaces are pressed together. If the friction surfaces are made

entirely flat so as to cover the complete areas within the circles that form the outlines of the disks, the tendency is for the wear, due to slipping, to be more rapid toward the periphery than at and near the center of the disk. In order to obviate this undesirable feature, which reduces the amount of turning effort that can be transmitted from one disk to the other, the disks are hollowed out so that a ring is formed at the periphery of each disk. Although, when modified in this manner, the bearing surfaces are no longer in the form of disks, the name *disk clutch* is yet applied to clutches of this type. As the bearing surfaces are flat and are at right angles to the direction of the force that is applied to close them, the pressure between the friction surfaces, instead of being greater than the closing force, as in cone clutches, is equal only to the amount of the closing force. Therefore, for a given diameter, an equal extent of friction surfaces, and the same closing force, a single pair of frictional surfaces will not transmit so much turning effort in the disk type of clutch as in the cone type.

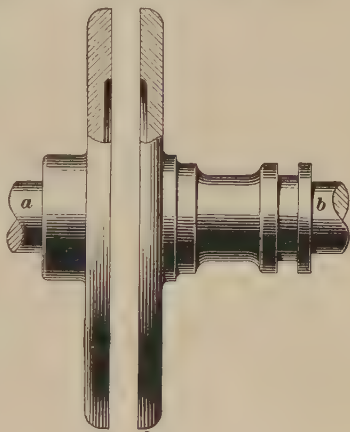


Fig. 7

22. In order to keep down the size of the disk clutch, as well as the closing force, a number of friction disks, or rings, are often used in automobile practice. The multiplication of the friction surfaces in this manner increases the turning effort that the clutch will transmit, in the same proportion as the number of pairs of frictional surfaces is increased. Thus, with two pairs of frictional surfaces, the turning effort will be twice as great as with one pair, provided, of course, the friction surfaces are of the same mean diameter and extent, have the same coefficient of friction, and are pressed together with the same pressure in each case. Thus, if there are thirty

pairs of friction surfaces, the clutch will transmit thirty times the turning effort that it would transmit with only one pair.

23. An idea of the extent of increase of frictional effect that is secured by increasing the number of pairs of friction surfaces can be obtained by the following simple experiment: As shown diagrammatically in Fig. 8, lay together a number of sheets, or slips, of writing paper on a board or a box so that the ends of alternate sheets will overlap each other half way or more, and place a weight, as *a*, of $\frac{1}{2}$ pound or more on top of the overlapping parts. The sheets are shown separated merely to make the illustration clear; they really touch each other. Grasp the free projecting ends *b* and *c* of the paper and pull the sheets apart in opposite directions, as indicated by the arrowheads, so that the overlapping sheets slip from between each other. Care should be taken not to lift or pull upwards so as to raise the paper and weight. First use two or three sheets; then increase the number of sheets to thirty or more.

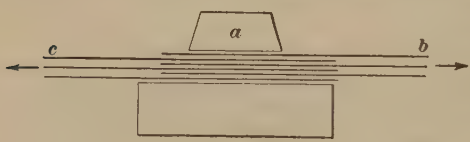


Fig. 8

The amount of pull necessary to draw apart thirty sheets will be rather surprising at first. This pull is proportional to the number of pairs of surfaces that slide, or rub, over each other.

24. Construction of Disk Clutches.—In general, plate clutches and multiple-disk clutches may be divided into two general classes, which are *dry-plate clutches*, or those in which the disks require no lubrication, and *oiled clutches*, or those in which the clutch is enclosed in an oil-tight case and runs in a bath of oil. In some cases the compartment containing an oiled clutch communicates directly with the crankcase of the engine, and therefore the clutch is oiled with engine oil; in other cases the clutch compartment is separated from the crankcase by an oil-tight joint, and the clutch is oiled by a mixture of kerosene (coal oil) and engine oil. The dry-plate clutch at present is more widely used in American automobile practice than the oiled clutch.

25. In the dry-plate clutch, lubrication is made unnecessary either by facing one set of disks with asbestos fabric on both sides or by making use of cork inserts. Both of these materials have good frictional qualities when used on steel. The asbestos fabric is composed of asbestos fiber and woven wire and is riveted to the plates. The asbestos is used on account of its good frictional qualities and its resistance to heat, while the wire is used to give the asbestos the necessary strength. Cork inserts in disk clutches serve the same purpose as in cone clutches; that is, they provide a means for obtaining a smooth and gradual engagement. When the clutch is engaged, the contact in cork-insert clutches is normally cork on metal. A drawback to the use of cork inserts in dry-plate clutches is that they are very liable to heat enough to burn out if the clutch is slipped too much; this fact has led to a gradual abandoning of cork inserts in dry-plate clutches, although these inserts are used today successfully in many oiled disk clutches.

The chief advantage of the dry-plate clutch is that it eliminates the dragging due to improper lubrication, by *dragging* being meant that the clutch fails to release properly when the clutch-operating pedal is pushed forwards.

26. The dry-plate clutch most widely used at present in American practice is manufactured for the trade under the name of the Borg & Beck clutch; it is of the single-plate type. While different models of this clutch, produced at different times, vary slightly in details of construction, yet all models embody the same principle of operation and have the same general features of construction and adjustment. Therefore, an illustration of one model of this clutch will serve to give a clear understanding of all other models made.

27. One model of a Borg & Beck clutch is shown in cross-section and end view in Fig. 9, and a number of the parts are shown in perspective in Fig. 10. As far as possible the same parts are lettered alike in both illustrations, and both should be referred to in reading the description.

The driving member of the clutch, when assembled, consists of the flywheel *a*, to the rear of which is bolted the clutch

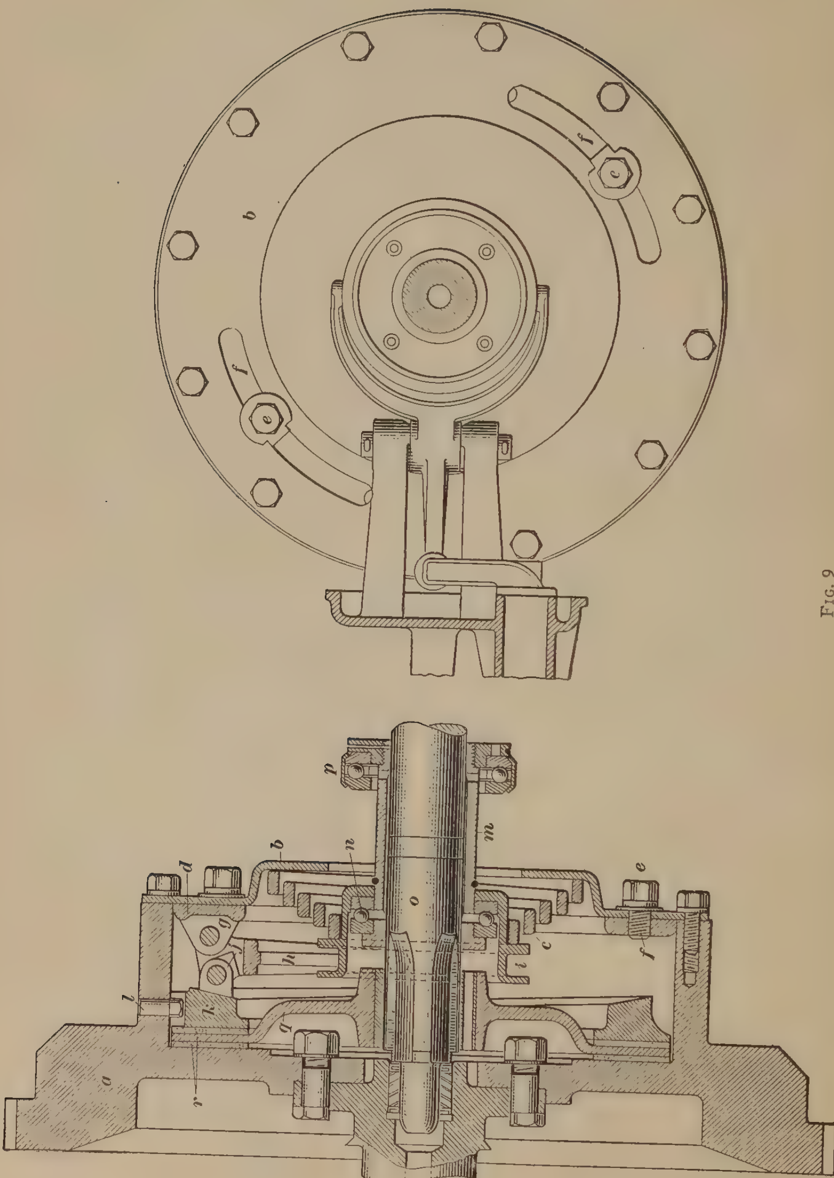


FIG. 9

cover *b*, which also forms an abutment for the clutch spring *c*; this spring *c* before being compressed is clearly shown in Fig. 10. The so-called adjusting ring *d* is bolted to the clutch cover *b* by two bolts *e* passed through circular slots *f* of the clutch cover; this permits turning the adjusting ring slightly in reference to the clutch cover and locking it again. This turning of the adjusting ring is only performed in adjusting the clutch in overhauling and repair work; in normal operation, both while the clutch is engaged or disengaged, the adjusting ring and clutch cover are locked together. The adjusting ring has three lugs *g* to which are pivoted forked bell-cranks *h*;

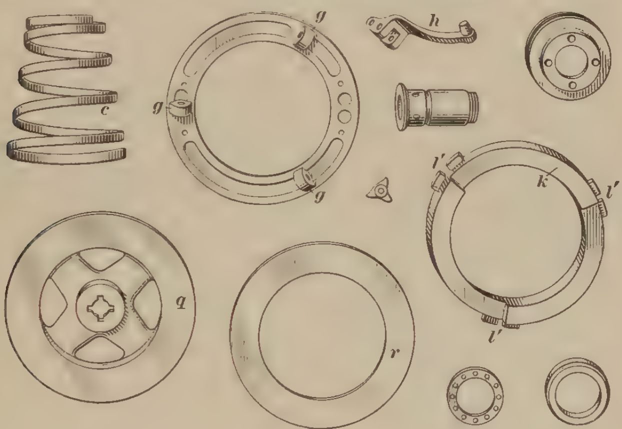


Fig. 10

the inner end of each bell-crank has a pin engaging a groove of the clutch spring collar *i*, which is normally forced forwards by the clutch spring *c*. Each bell-crank *h* has pivoted to it a shoe *j* that bears against the rear face of the thrust ring *k*; this thrust ring is movable lengthwise, but is forced to turn with the flywheel *a* by three pins, as *l*, set into the flywheel and engaging three slots *l′* of the thrust ring. The clutch spring collar *i* in this particular design is free to turn easily on the clutch sleeve *m*, a ball thrust bearing *n* being provided; the sleeve *m* is free to rotate on the clutch shaft *o* connected to the propeller shaft or the transmission. The clutch sleeve *m* carries at its rear end the clutch thrust-collar ball bearing *p*,

against which operates the mechanism of the clutch pedal used for disengaging the clutch, by drawing the clutch sleeve *m* to the rear.

The driven clutch member *q* has a splined hub, which fits over the splined forward end of the clutch shaft *o*, and hence the member *q* while free to slide lengthwise is forced to rotate with the clutch shaft. The necessary friction surfaces for engaging the clutch properly are two wire-woven asbestos thrust disks *r*, which are not fastened in any way; one of these thrust disks is placed between the inner face of the flywheel and the forward face of the driven member *q*, and the second thrust disk is placed between the rear face of the driven member and the thrust ring *k*.

28. The clutch shown in Figs. 9 and 10 is normally in its engaged position, like all other clutches used for the same purpose. The clutch spring *c* presses the clutch-spring collar *i* forwards; this swings the bell-cranks *h* forwards and upwards, and causes the shoes *j* to press forward the thrust ring *k* and thus firmly presses together the thrust disks *r*, the driven member *q*, and the flywheel. When the clutch pedal, not shown, is depressed, the clutch sleeve *m* is drawn to the rear, thereby also drawing the clutch-spring collar *i* to the rear. This swings the bell-cranks *h* rearwards and their forward upper end downwards, thus drawing the shoes *j* to the rear; the closing pressure is thereby removed from the thrust ring *k*, the clutch disks *r*, the driven member *q*, and the flywheel, and the clutch is now disengaged.

Provision for taking care of wear of the friction surfaces is made by the construction of the thrust ring *k*. The rear of this ring is not flat, but has three cams, or, in other words, is divided into three equal inclined surfaces, as indicated in both Figs. 9 and 10. By partly turning the adjusting ring *d*, it is possible to change the distance between the pins around which the bell-cranks *h* turn and the rear face (the inclined surfaces) of the thrust ring *k*; a total change of about $\frac{1}{4}$ inch is provided for, thus giving an ample margin for adjustment before the disks *r* need replacement.

29. Some of the models of the Borg & Beck clutch are provided with a clutch brake for slowing down the driven member when the clutch is released, but in other models, like that shown in Figs. 9 and 10, the clutch brake is omitted. The clutch brake used consists simply of a flat metal disk fastened to the clutch shaft *o*, Fig. 9, to the rear of the clutch thrust-collar ball bearing *p*, and a flat friction disk attached to the clutch throw-out yoke; this brake is brought into action by pressing the clutch pedal far enough forwards.

30. It is an essential feature of all disk clutches of the multiple-disk type that there be two sets of disks, the one set forming part of the driving member of the clutch and the second set forming part of the driven member. Each set must be movable lengthwise in respect to the crankshaft, and each set must be positively driven by, or must positively drive, the clutch member of which it forms a part.

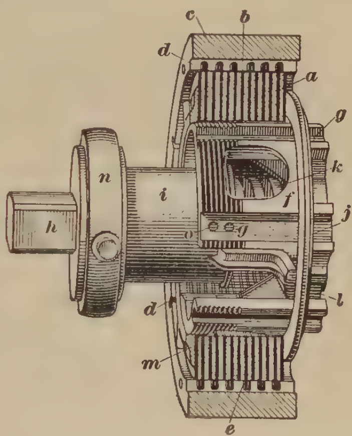


Fig. 11

31. Different driving methods for clutch disks are used in practice. One of the earliest methods is that shown in Figs. 11 and 12, which do not illustrate any particular make of multiple-disk clutch, but are given to point out the general assembly of such a device, of the dry-plate type. The plates *a* and *b* and the driving member *c*, Fig. 11, are shown cut in half with the front halves removed in order to expose to view the inner parts of the clutch. The disks consist of driving plates *a*, which are faced on both sides with asbestos fabric, and driven plates *b*. Formerly the asbestos fabric was cut from strips and riveted on in pieces, but proper friction fabric is now manufactured in ring form in many standard sizes. The friction disks are in reality rings and are provided with projections

that engage with grooves in the driving and driven members of the clutch. The driving member *c* is a hollow cylinder attached to, or forming part of, the flywheel, and is provided with grooves *d* that engage with the projections *e* on the driving disks *a* in such a manner that the disks are free to slide in the grooves but must rotate with the hollow cylinder.

The inner member *f* is also provided with grooves *g*; these grooves engage with projections on the inner edge of the

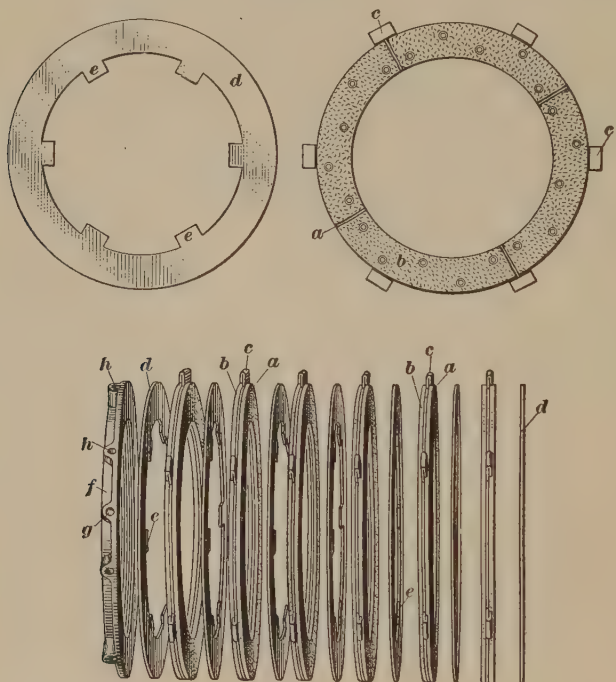


Fig. 12

driven disks *b*, which are free to slide in the grooves but must rotate with the driven member *f*. This member is part of the driven shaft *h*. Inside of the inner member *f* and surrounding the shaft *h* is the spider *i*, of which the ring *j* is an integral part. The clutch-closing spring *k* is contained within the spider *i* and is compressed between a shoulder in the outer end of the spider sleeve and a web *l* of the inner member *f*.

The friction disks are confined between the ring *j* and a large nut *m* that is screwed on the inner member *g* and serves as a means of adjusting the pressure on the disks. The clutch is operated from a pedal through the yoke *n*.

32. When in operation on the car, the driving member *c*, Fig. 11, of the clutch is bolted to the flywheel of the engine and rotates with it, carrying around the driving plates *a*. The shaft *h* is coupled to the transmission of the car. When the clutch pedal is released to engage the clutch, the spring *k* expands, forcing the sleeve *i* and the web *l* apart and moving the ring *j* and the adjusting nut *m* closer together. The disks *a* and *b* are thus forced together and the rotary motion of the driving disks *a* is imparted to the driven disks *b*. The driven disks *b* in turn cause the inner member *f* to revolve and this turns the shaft *h* that is coupled to the driving mechanism of the car. Thus, power is transmitted from the engine to the propeller shaft when the clutch is engaged. The clutch is disengaged by depressing a pedal that forces the yoke *n* forwards, or toward the web *l*, compressing the spring *k*. This movement forces the ring *j* and the nut *m* farther apart, thus relieving the pressure on the disks and permitting the driving plates *a* to revolve without turning the driven plates *b*. This disconnects the engine from the driving mechanism of the car and permits the motor to run freely.

A gradual engagement can be obtained by allowing the pressure of the spring to come gradually on the plates, so that the driven disks will slip at first and then gradually speed up until they have the same speed as the driving member. The clutch is adjusted by turning the nut *m* to the right or the left, thus increasing or decreasing the compression of the spring when in the engaged position.

33. The friction disks of the clutch shown assembled in Fig. 11 are illustrated disassembled in Fig. 12. Each driving disk is made up of a steel ring *a* faced on each side with wire-woven asbestos *b*, which in this case is in sections and is secured to the ring by means of copper rivets. The rivets

are countersunk in the asbestos to prevent their heads from coming in contact with the adjacent disks. The projections for holding the disks in the cylindrical driving member are shown at *c*. The driven clutch plates *d* are of steel, but are plain, and have projections *e* on the inner circumference to prevent their turning on the driven member of the clutch. When the clutch is assembled, the adjusting nut *f* is locked in place by means of a lock pin that passes through a hole *g* in the nut and a corresponding hole in the inner clutch member. Several holes *o*, Fig. 11, are drilled in the inner clutch member so that the nut can be locked in different positions. Holes *h*, Fig. 12, in the adjusting nut are used for turning it for adjustment.

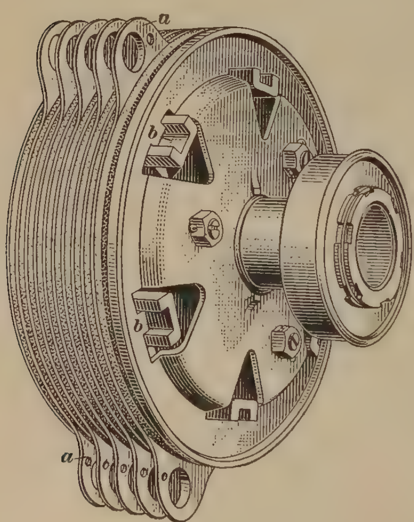


Fig. 13

34. In some models of the Chalmers, and also other makes of cars, the driving clutch disks, as shown in Fig. 13, have a number of lugs *a* formed on them, with circular holes. Circular studs or pins project from the face of the flywheel and pass through the lugs of the driving disks. The driven disks in this case have rectangular lugs on their inside, that fit corresponding grooves *b* of the clutch spider which forms part of the driven clutch member.

35. Fig. 14 shows the multiple-disk dry plate clutch of some models of the Buick car, removed from the unit power plant; the side facing the reader is placed toward the flywheel. Lugs *a* with rectangular slots are formed on the outside of the driving disks; these slots fit over studs carried by the flywheel, which studs drive the disks. The studs referred to

are omitted in the illustration in order to show the slots clearly. The driven disks are notched with rectangular notches on their inside, which fit over corresponding keys *b* of the clutch spider *c*, the latter forming part of the driven clutch member.

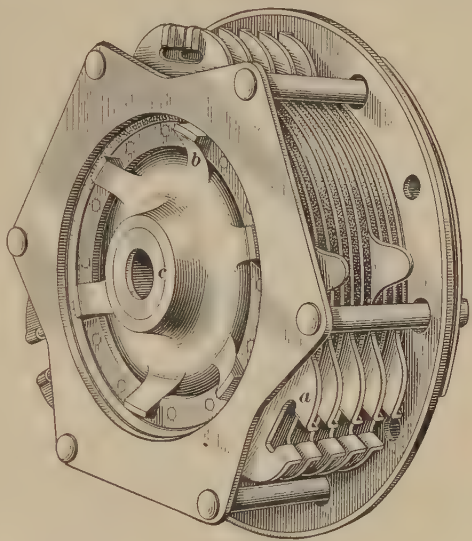


Fig. 14

36. The usual method of forming lugs with broad wearing surfaces, on driven disks of multiple-disk clutches employing a grooved spider, is clearly shown in Fig. 15, which is a view of a driven disk from the clutch of a Packard Twin-Six car. The lugs *a* have ears *b* bent up at right angles, so as to bear against the sides of the grooves of the clutch spider. This gives a comparatively low pressure per unit of area against the sides of the grooves, thereby promoting long wear of the clutch spider and disks.

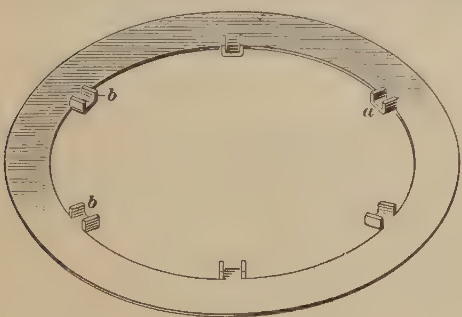


Fig. 15

37. In some multiple-disk clutches, both the driving disks and driven disks are mounted on studs; an example of this is found in some models of the Hupmobile car, and is illustrated in cross-section in Fig. 16. There are four driving disks *a* mounted on several circular studs *b* fastened to the flywheel *c*;

there are three separate driven disks *d*, which together with the clutch spider or clutch front pressure plate *e* and clutch rear pressure plate *f* are faced with friction fabric riveted on. The two clutch pressure plates and the three driven disks, etc. form the driven part of the clutch. The driven disks are mounted on studs *g* fastened to the front pressure plate *e*, which studs pass loosely through the rear pressure plate *f*. All disks are normally pressed firmly together by several springs *h* mounted on clutch spring studs *i* fastened to the front pressure plate *e*. The clutch is released, when the clutch pedal is pressed forwards, by projections of the forked clutch release lever *j* bearing against the ball-bearing clutch release collar *k*, thereby compressing the clutch springs *h* and drawing the rear pressure plate *f* rearwards. A friction facing *l* bears against a flange of the clutch pressure plate sleeve *m* when the clutch pedal is pressed fully forward, and serves as a clutch brake for slowing down the driven clutch member. The facing *l* is riveted to the forward end of the transmission housing.

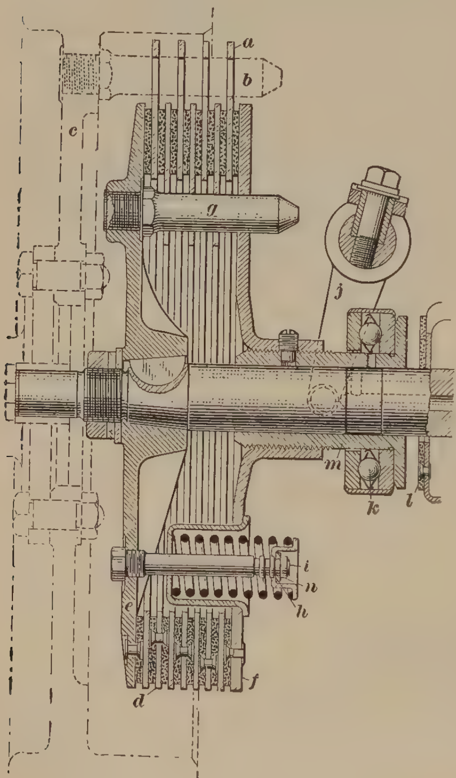


Fig. 16

In this particular design of clutch the tension of the clutch springs can be adjusted by changing the position of the clutch

spring collars *n* on the clutch-spring studs *i*. These studs are grooved, as shown, and a lock in the form of a horseshoe is dropped into one of the grooves to retain each collar *n*.

38. If the disks of multiple-disks clutches can rock a considerable amount in the car from the right to the left, or the left to the right, they will rattle annoyingly when the clutch is released while the engine is running. Such looseness, assuming the disks to have been fitted correctly in the first place, is due to wear of those parts of the disks that cause the driving disks to be positively driven from the driving clutch member, and the driven disks to drive positively the driven clutch member. This wear is greatly reduced by increasing the area of contact of the parts mentioned, thereby decreasing the pressure per unit of area. Incidentally the giving of a very low pressure at the points under discussion facilitates disengagement of the driving and driven disks from each other when the clutch pedal is depressed.

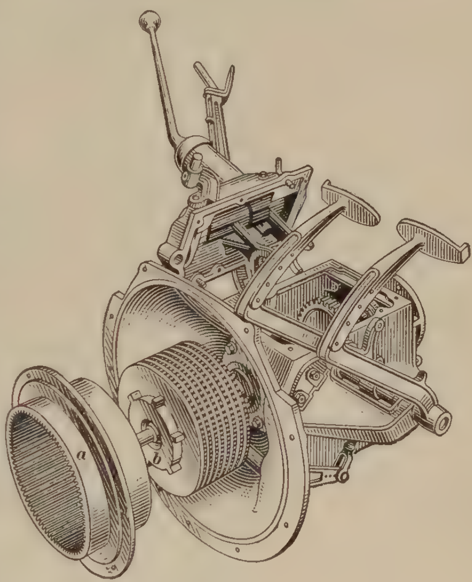


Fig. 17

A very large area of contact at the points under discussion is secured by forming gear teeth on the disks; Fig. 17 illustrates, partly disassembled, the clutch used in one model of the eight-cylinder Cadillac car. This has seventeen disks, there being eight driving disks and nine driven disks. The driving disks are faced on both sides with asbestos friction fabric; the driven disks are plain. The object of making the driven

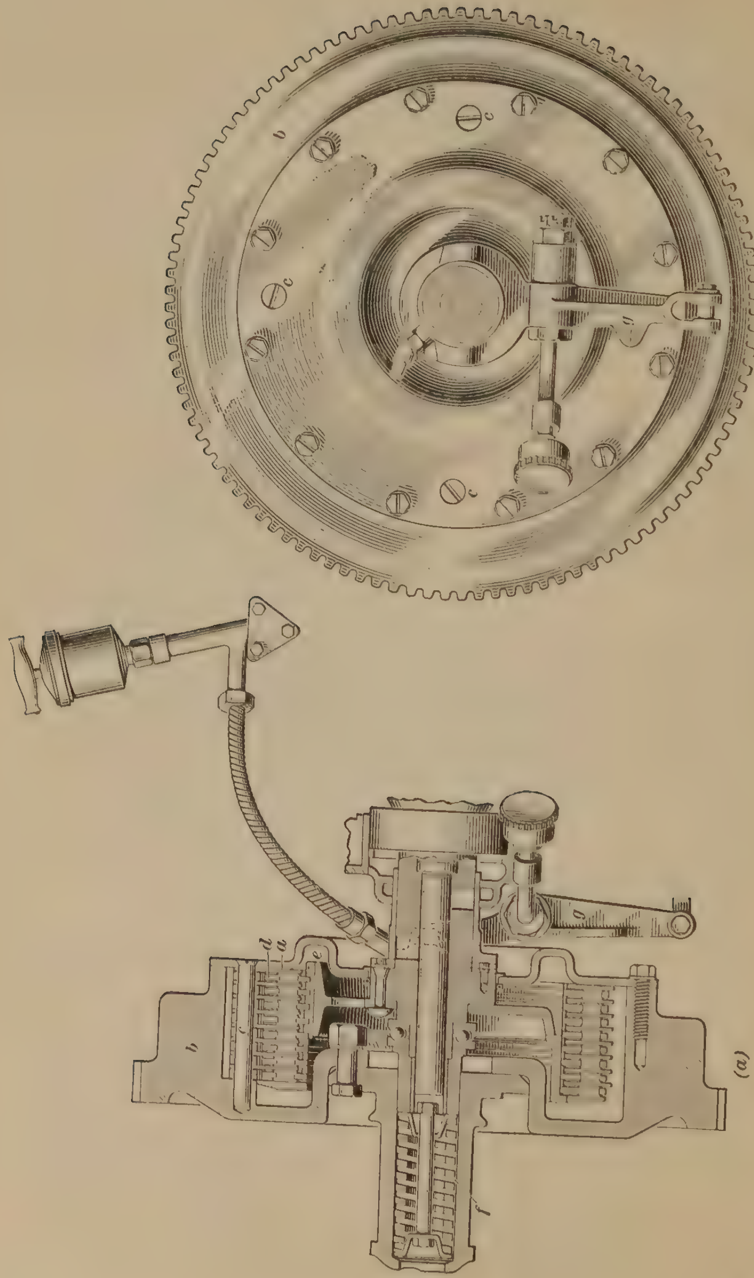


Fig. 18

disks plain is to reduce the weight of the driven clutch member, thereby decreasing its tendency to spin under its own inertia when the clutch pedal is depressed, which in turn contributes to quiet gear shifting. The outer circumference of each driving disk has eighty-one gear teeth cut on it, which engage with the spaces between corresponding teeth of the clutch driving ring *a* that on assembly is bolted to the flywheel, not shown. The nine driven disks each have six slots on their inner circumference, engaging six corresponding splines of the clutch spider *b*.

39. While multiple-disk clutches running in oil were widely used at one time, their use is now waning, chiefly on account of their rather high first cost. Many such clutches were constructed with the clutch disks running metal to metal, that is, without any friction fabric facing for the one set of disks. Some very successful clutches of the type under discussion employ cork inserts in the one set of disks, the corks projecting slightly from the faces of the disks in which they are inserted. As the corks are quite elastic, and also have a high friction, they make a very *soft* clutch, as it is called, meaning thereby that they contribute toward a very gentle engagement, which is a desirable feature. It is advisable to provide special means for promptly separating upon disengagement the clutch disks of all multiple-disk clutches running in oil, as the oil, even if well thinned out with kerosene, is somewhat sticky.

40. An example of a multiple-disk cork-insert clutch running in oil is found in many Hudson cars; this clutch is shown in cross-section in Fig. 18, and separate perspective views of one of the driving and one of the driven disks are presented in Fig. 19. There are eight plain steel driving disks *a*, which have four lugs on their outer circumference, there being circular holes in the lugs; these disks are driven from the flywheel *b* by four studs *c* passing through the holes of the lugs. These driving disks are punched from flat steel about $\frac{1}{16}$ inch thick, and are $1\frac{1}{4}$ inches wide. There are eight driven disks *d* about $1\frac{1}{8}$ inches wide punched from steel about $\frac{3}{16}$ inch thick, into which, as

clearly shown in Fig. 19, are inserted a large number of cylindrical pieces of cork that project about $\frac{1}{32}$ inch on each side

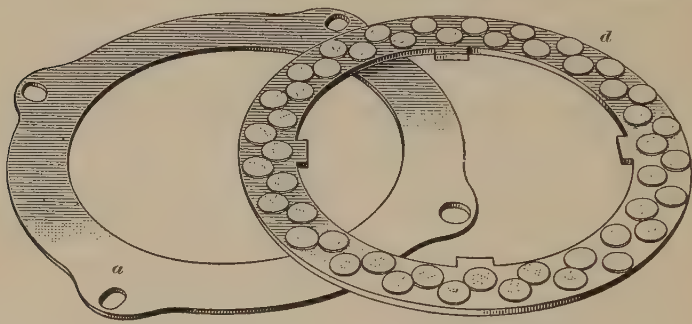


FIG. 19

of the steel disks. The driven disks have four equally spaced lugs on their inner circumference, which engage corresponding grooves of the clutch spider *e*, Fig. 18, thus driving the driven clutch member when the clutch is engaged. The single clutch spring *f* normally presses all the disks together. To insure prompt release of the clutch, helical springs are placed over the studs *c* and between each pair of driving disks *a*. The clutch is released when the clutch pedal is depressed, through the forked lever *g* pushing the clutch spider *e* forwards, thereby compressing the clutch spring.

FIG. 20

The flywheel and clutch are enclosed in an oil-tight casing forming part of a unit power plant; this casing is partly filled with a mixture of one-half kerosene and one-half engine oil.

41. A method that has sometimes been employed to separate the disks of multiple-disk clutches running in oil is to provide springs formed by bending back strips partly cut from the metal disk, as shown at *a*, Fig. 20. These bent-up ends, or tongues, are formed on alternate disks, usually the driving disks. When the clutch is engaged, they flatten down, but when it is released, they spring out, forcing the plates apart.

In addition to overcoming the sticking tendency of the friction surfaces, the separating springs must overcome the frictional resistance to the sliding of the disks along the arms or keys that drive them. If the clutch is transmitting considerable power at the instant it is released, there is considerable frictional resistance to the sliding of the disks along these parts.

CONTRACTING AND EXPANDING CLUTCHES

42. While clutches having a band on the driven clutch member, which band either contracts on, or expands into, a cylindrical drum that is part of the flywheel, are not fitted to

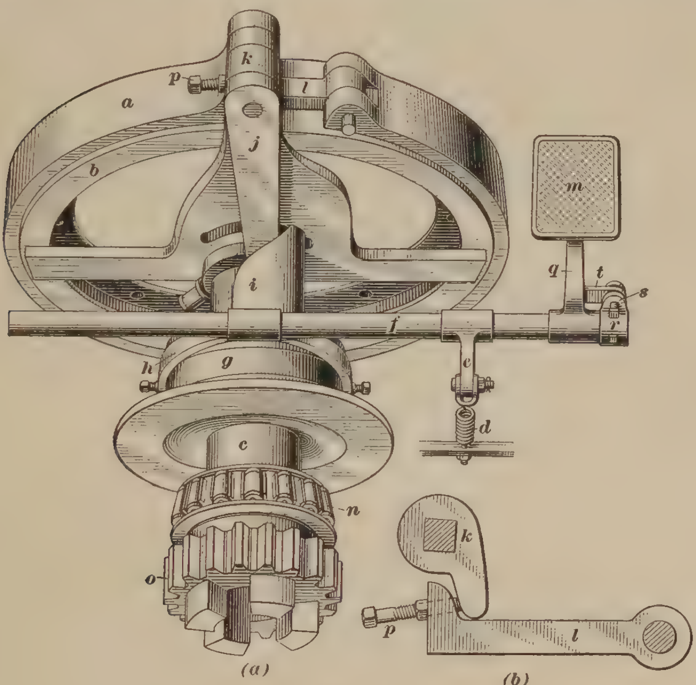


Fig. 21

new cars at present, they are found frequently on old cars still in use, and therefore a brief description of one of each type is warranted. The Haynes clutch, which is illustrated in

Fig. 21, and which was used for several years in this car, is an example of the contracting band type. In this clutch, which is shown in the released position in view (*a*), the friction is obtained by tightening the steel band *a* around the steel drum *b*. The band *a* is mounted on a short shaft *c*, which is connected to the transmission, and the drum *b* is bolted to the engine fly-wheel; hence, when the clutch is engaged, power is transmitted directly from the engine to the transmission.

An uncommon feature of this clutch is the type and location of the clutch spring *d*. This spring is attached at its upper end to the lever *e* and at its lower end to some part of the automobile frame, so that when it is allowed to contract, it turns the clutch shaft *f*, which slides the collar *g* forwards by means of the yoke *h*. The collar carries a wedge-shaped shipper head *i*, which, when pressed forwards with the collar, forces the lever *j* to one side, thereby drawing the ends of the band *a* together and engaging the clutch. The manner in which the lever *j* brings the clutch in engagement is shown in view (*b*). Attached to the upper end of the lever by means of a squared pin is a latch *k* that engages with a catch on the end of the strap *l*. As the lever *j* is swung to the left, it turns the latch *k* and draws the strap toward it, tightening the band and engaging the clutch.

The clutch is released, or disengaged, by pressing forwards on the foot-pedal *m*, which turns the shaft *f* against the expansion of the spring *d*. The yoke and shipper head are thus drawn away from the clutch, the lever *j* takes the position shown in (*a*), and the ends of the band *a* spring apart. The drum *b* is then free to rotate without turning the band *a* and the engine can be run free.

At *n* is shown a roller bearing for supporting the shaft *c*, and at *o* is the gear by means of which the shaft drives the transmission gears. In some models of the Haynes clutch, the lever *j* and latch *k* are held in the released position by a small helical spring, which prevents any rattling of these parts. Adjustment of the Haynes clutch is made by a setscrew *p*. The clutch band is tightened by screwing this setscrew into the end of the strap *l*.

43. In band clutches of the expanding type, the inner member is of variable diameter and the outer member is a drum attached to or integral with the flywheel. In this type of clutch, the required friction is obtained by expanding the inner member until its outer surface makes contact with the inner surface of the outer member. As in the other types of clutches, the inner member is connected to the transmission shaft, so that when the clutch is fully engaged the engine crankshaft is directly connected to the transmission shaft. The force of the clutch-closing spring may be transmitted to the expanding band either by means of levers or by a right-and-left screw.

44. The clutch used on some of the older models of the Peerless car is an example of an expanding band clutch employ-

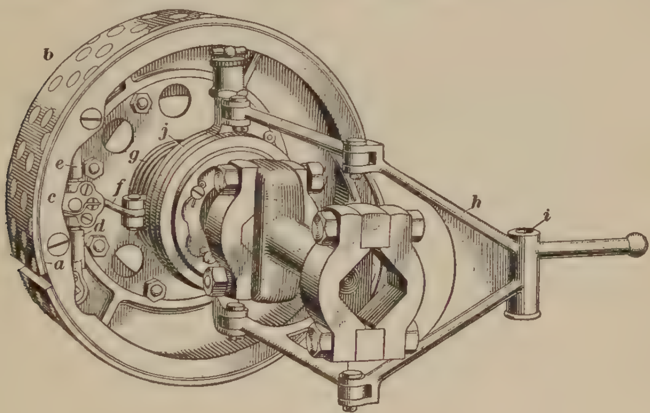


Fig. 22

ing a right-and-left screw to expand the inner member. A perspective view of the inner member of this clutch is shown in Fig. 22. The expanding part is a steel band *a* that is covered with a leather facing *b* provided with cork inserts. The band is fixed at one end to the clutch drum *c* and at the other, which is free from the drum, to one end *d* of the expander arm. The drum contains a slot, through which the band is secured to the expander arm by means of a bracket. The other end *e* of the arm is attached to the drum. Inside

of the expander arm and running its entire length is a screw that contains a right-hand thread at one end and a left-hand thread at the other, which turn in corresponding threads in the ends of the expander arm. This screw is turned by the link *f*, and when this link is drawn toward the rear of the car, or away from the clutch drum, by the expansion of the closing spring *g*, it rotates the screw in the direction that will force the ends *d* and *e* of the expander arm apart and thus expand the band *a*. As the band expands, the leather facing takes hold of the inner surface of the flywheel drum, thus engaging the clutch.

The clutch is disengaged, or released, by a pressure on the clutch pedal, which, through a suitable rod, swings the operating lever *h* on its fulcrum at *i* and compresses the spring *g* by means of the collar *j*. This movement of the collar rotates the right-and-left screw in the direction necessary to draw the ends of the expander arm toward each other and thus contract the band *a*, allowing the flywheel to revolve freely. When placed in the car, the fulcrum *i* is carried on a pressed-steel bracket that is attached to a side member of the frame.

CLUTCH OPERATION

CLUTCH-ACTUATING MECHANISM

45. Pedal Connections.—Friction clutches for automobiles are now invariably operated by a pedal that projects upwards through the floor boards of the car and is within easy reach of the driver's left foot. Generally, when engine and transmission are separate units, this pedal is carried on a tubular shaft that extends part or all of the way across the frame of the car and is supported by brackets on members of the frame. This shaft also carries a yoke, by means of which the clutch is released when the pedal is pressed forwards. In the unit power plant type of construction, the clutch pedal is usually supported by a short shaft that is carried by the clutch casing. Clutch pedals are attached in a variety

of ways. Sometimes they are simply keyed or clamped to the shaft, when they cannot be adjusted in any way. In other cases, they are made adjustable and can be lengthened or shortened within certain limits to suit the height of the driver of the car and thus add to his comfort.

In American standard practice the clutch pedal is always operated by the left foot of the driver. As a general rule the clutch pedal, with sliding gear transmissions, only operates the clutch; in a few cases the clutch pedal when pushed all the

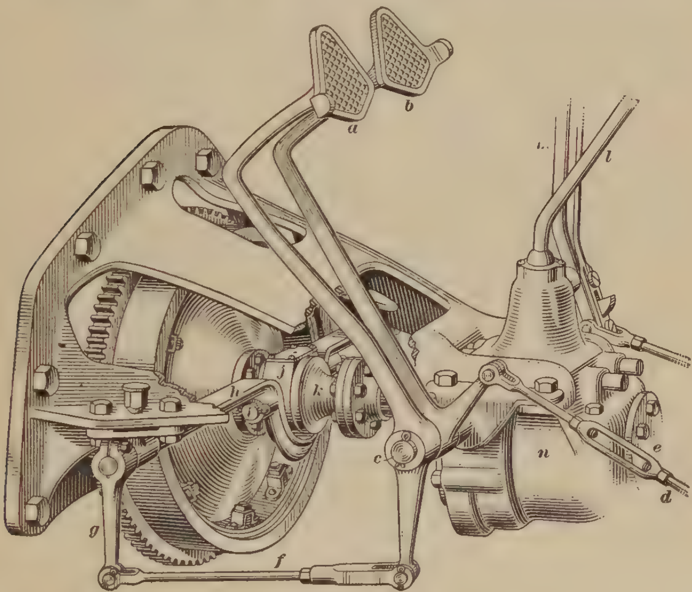


FIG. 23

way forward brings the service brake into action. In the Ford car, which does not employ a sliding gear transmission, but a planetary one, the low transmission speed and the high-speed clutch (in this car the clutch is only engaged when in direct drive) are operated by the clutch pedal, which when released engages the high-speed clutch, when pushed half way forward releases the high-speed clutch, and when pushed forward as far as it will go, brings the low-speed gearing into action.

46. Fig. 23 illustrates in perspective the clutch-actuating mechanism of several models of the Chevrolet car, which uses a leather-faced cone clutch that is drawn to the rear to release it. In this construction the clutch pedal *a* and service brake pedal *b* are mounted loosely on a shaft *c*. The rod *d* with a turnbuckle *e* is used for adjusting and operating the service brake. The clutch pedal is connected by an adjustable rod *f* and lever *g* to a cross-shaft *h* yoked at its middle to encircle the clutch spider. This cross-shaft is connected by pins, as *i*, to the clutch release collar *j*, which in turn, when the clutch pedal is depressed, bears against the forward face of the clutch thrust ring *k*, thus drawing the inner clutch member to the

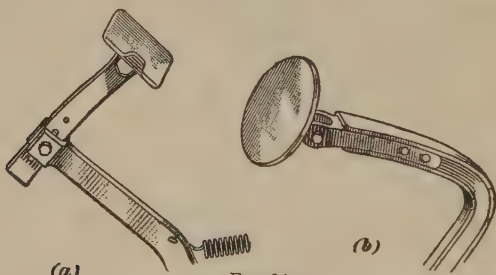


FIG. 24

rear. A single clutch spring is used, which is inside the clutch spider, and therefore cannot be seen.

The gear shift lever *l* and emergency brake lever *m* are mounted on top of the transmission, and therefore are in the center of the driving compartment of the car. The clutch pedal and brake pedal are on the left side of the car, which has left-hand steering, as is most common in American cars.

47. Adjustable Pedals.—The pedals used for operating the clutch and service brakes are made adjustable for length in a large number of automobiles, the object being to bring the pedals within convenient reach of the operator. Adjustable pedals are made in a variety of forms and are quite simple in construction. A common type is the **bolt-adjustment pedal,** examples of which are shown in Fig. 24. In view (*a*), the shank of the pedal is fastened to the pedal lever by a through bolt and the pedal can be raised or lowered by making

use of different holes in the shank. In some pedals of this form two bolts are used, while in still other cases the shank

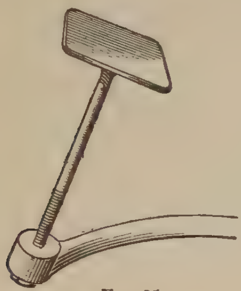


Fig. 25

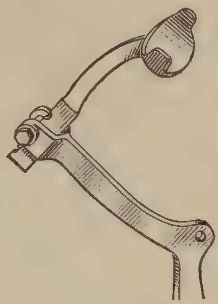


Fig. 26

slides over the lever, which is bent at approximately a right angle, as shown in (*b*).

Another form of adjustable pedal is the **screw pedal,** illustrated in Fig. 25. In one form the pedal shank, or spindle, screws into the tapped end of the lever and a lock-nut is placed directly on the shank, underneath the lever. In this design of pedal, the pitch of the threads usually is not very steep and the adjustment secured by turning the pedal through one revolution is close enough for all practical purposes.

In some pedals, a **jaw-clamp adjustment** is employed, which is usually made as shown in Fig. 26. The end of the pedal lever contains a jaw clamp. The shank of the pedal contains corrugations, or notches, in which the bolt fits. The bolt passes through the jaws at the end of the pedal lever and adjustment is made by removing the bolt and sliding the desired notch in place.

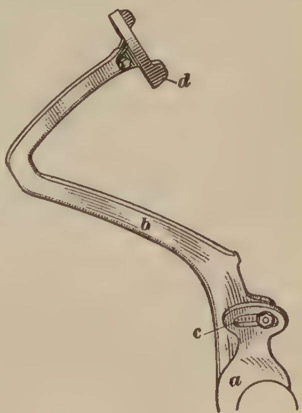


Fig. 27

There are, of course, other designs of adjustable pedals than those shown, but the principle is the same in all. Practically the only difference is in the details of construction.

Some clutch pedals are constructed without any means of lengthening or shortening them, but the position of the pedal itself can be changed. A simple device which accomplishes this object is shown in Fig. 27. In this design, the hub *a* is attached to the shaft and the lever *b* is connected to the hub by means of a bolt that passes through the slot *c*. The pedal lever is free to revolve on the rod; hence, adjustment is made by loosening the nut and turning the lever to the desired position, after which the nut is again tightened. A noticeable feature of this pedal is that the face *d* can be tilted to any angle desired by loosening the nut in the pedal face and placing it in the desired position.

USE OF CLUTCH BRAKE

48. In order to obtain the best results from the use of the clutch brake, it is necessary to know when to use it and the extent to which it should be used for different conditions. The transmission gears that are to be meshed when changing speeds must have practically the same circumferential velocities in order to make possible a silent shift; hence, for different conditions the brake must be used in different ways. When starting the car, the driven gears of the transmission are at rest; therefore, the clutch pedal should be fully depressed so as to apply the clutch brake fully and bring the driven member of the clutch and the driving gears of the transmission also at rest.

When changing from a low to a higher gear, the driven gear of the transmission is running slower than the driving gear that is to be meshed with it; hence, it is necessary to slow down the driving gear but not to stop it entirely. This is done by releasing the clutch but not fully depressing the pedal, or, in other words, by partly bringing the clutch brake into operation. Experience with any particular car is required to ascertain exactly how far to depress the clutch pedal in order to obtain the desired result.

When changing gears from a higher to a lower speed, the clutch pedal should be operated so as not to bring the clutch brake into action, because during this operation the speed of the driving gear of the transmission is less than that of the

driven gear and any application of the clutch brake will decrease it still further. The speed of the driven member of the clutch and of the driving gear of the transmission can then be allowed to increase with the engine speed while the gears are in neutral until practically equal circumferential velocities of the meshing gears are obtained.

FRICTION MATERIALS FOR CLUTCHES

49. In cone clutches, the outer cone is generally made of gray cast iron, semi-steel, or is a steel casting, and the inner cone is of aluminum, cast iron, or pressed steel. The inner cone is usually faced with leather, but occasionally with some kind of asbestos fabric, known by various trade names, such as raybestos, multibestos, thermoid, etc. Cork has at one time been used as a friction material in the form of inserts in the leather facing. Metal-to-metal cone clutches have also been used to some extent, but these are not employed at present.

When metal is used on leather or asbestos fabric, no lubrication of the rubbing surfaces is required; in fact, the presence of a lubricant between these surfaces is generally injurious and detrimental to the operation of the clutch. However, a small quantity of castor oil or neat's-foot oil should periodically be applied to the leather of a cone clutch for the purpose of keeping it soft. Before applying this oil, the leather should be thoroughly washed in gasoline, if this can be done, and then a generous quantity of oil used.

While in general engine oil is detrimental to cone clutches, an asbestos-fabric faced cone clutch running in oil is used satisfactorily in some Maxwell cars.

The friction disks of multiple-disk clutches, when entirely of metal, are ordinarily of steel, or one set of disks is of steel and the other set of bronze. In the former case, the friction surfaces, of course, are steel on steel, and in the latter case, bronze on steel. Usually, however, one set of disks is faced with asbestos fabric or provided with cork inserts. The steel used to a considerable extent for the disks of all metal friction clutches is of the same quality as that used in common wood saws and is known as *saw-blade steel;* for clutches with

one set of faced disks the disks are usually cut from hard rolled, highly finished, sheet steel.

In the case of expanding or contracting clutches, both friction surfaces are sometimes steel, or one may be a cast-iron or steel casting and the other brass or bronze.

TRANSMISSION AND CONTROL MECHANISM

(PART 2)

TRANSMISSION MECHANISM

SPEED-CHANGING MECHANISM

PURPOSE

1. Since a gasoline automobile engine depends upon its own motion to draw in combustible charges, and since a certain minimum force is required to overcome the engine friction, it follows that for each engine there is a speed below which it cannot run. There is also a maximum speed beyond which an engine cannot run without impairing its efficiency.

In order that the engine may drive the car, it must exert sufficient *torque, or turning effort,* at the driving wheels to overcome the car resistance. This torque required at the driving wheels varies naturally between very wide limits, depending on road conditions and car speed. Thus, a large torque at the driving wheels is required when ascending a steep hill, and a very small torque when driving on the level on a paved road. But, the smallest and largest torque that can be exerted by an internal-combustion engine between its lowest and highest speeds are limited, and hence the difference between the two torques, or the *torque range* as it may be called, is rather small.

This lack of torque range of the internal-combustion motor must be compensated for in a gasoline car by fitting a *change-*

speed gear, more popularly known in the United States as a *transmission.* With this device the ratio of engine speed to driving-wheel speed can be changed in several steps, thereby obtaining a large torque range at the driving wheels with a small torque range of the engine.

2. The torque range of a gasoline automobile engine can be increased by multiplying its cylinders and increasing their capacity, but there are practical, yet not absolutely definite, limits to the increase of these factors to the point where the transmission can be dispensed with. These practical limits are the first cost of the power plant, and the increased costs of operation and maintenance. If these costs are to be kept within range of what the average car buyer can afford, experience has demonstrated that twelve is the limit in the number of cylinders and 500 cubic inches total piston displacement, the limit of capacity. By **total piston displacement** is meant the product of the cylinder bore in square inches, the stroke in inches, and the number of cylinders.

3. As the four-cylinder gasoline engine applied to automobiles is irreversible, it is necessary, in order to go backwards, to change the direction of rotation of the driving wheels by bringing into action a mechanism that will reverse the car. This mechanism is called the *reversing gear,* or *reverse,* for short, and is incorporated in all transmissions.

4. The transmissions, which either have been most widely used, or are employed today in gasoline-propelled vehicles, may be divided into five general classes, depending on the principle on which they operate. These classes are *sliding change-speed gears, planetary change-speed gears, electric transmissions, friction transmissions,* and *individual-clutch gear transmission.* Of these classes the one first named is most widely used. The second class is limited almost entirely to the Ford car and a few trucks; the third class, in spite of its general excellence, owing to price and patent considerations, is limited virtually to one make of car, and the fourth class today is obsolete. The fifth class is now being used in some trucks. Types of transmissions other than those here named have been built, or

are being built, on a small scale, but have not come into extended use.

With sliding change-speed gears, the mechanism is usually operated by the driver through a lever, although air under pressure and electric current have been and are still being used to a limited extent for gear shifting. With planetary change-speed gears control of the mechanism is usually by two or more pedals, although a combination of pedals and levers has been used in early models of cars. Thus, the use of a lever for engaging high gear, and pedals for low-speed and reverse, was at one time very common.

SLIDING CHANGE-SPEED GEARS

5. Classification.—In the sliding-gear transmission, hardened steel spur gears are carried on two parallel shafts; one of these is in two parts, a forward or driving part and a rearward or driven part; the other shaft is a *countershaft,* or *jack-shaft,* through which the power is transmitted for certain speeds. The various speeds are obtained by sliding the gears lengthwise on the main shaft and securing the desired speed ratio by bringing them in mesh with the proper gears on the countershaft. For what is known as the *direct drive,* the two parts of the main transmission shaft are locked together, forming a direct drive from the engine to the rear axle. Sliding-gear transmissions are ordinarily designed to give either three speeds forwards and one reverse, or four speeds forwards and one reverse. The former is popularly called a *three-speed transmission,* and the latter a *four-speed transmission.*

6. Sliding change-speed gears are constructed in two general types, one of which is known as the *selective transmission,* and the other as the *progressive transmission.* In the selective transmission, the change can be made from any speed to any other while the car is traveling, as from slow speed to high speed; but in the progressive transmission, the change from slow to high speed, as well as from high to slow speed, must be made step by step through all the speeds. The progressive transmission, while very popular at one time, has been super-

seded by the selective transmission, and is now found only on a few old cars. There are two types of selective and progressive transmissions, namely, the *horizontal* and the *vertical*. In the so-called horizontal transmission, the two shafts on which the change-speed gears are mounted lie in the same horizontal plane, while with the vertical transmission the shafts lie in a vertical plane, one above the other. The horizontal and vertical transmissions do not differ in principle of operation.

Practically all makes of selective transmission, whether manufactured in the shops of the car builder or bought of a gear specialist, are of the *constant-mesh* class. By this is meant that the gear on the forward part of the main transmission shaft and the gear on the countershaft with which it meshes, are constantly meshed. In consequence of this the countershaft gears turn constantly when the transmission is in high gear and the car is running with the clutch engaged. The makers of the Dodge car, however, have designed and patented a selective transmission, used only in their car, in which no gears are in mesh when high gear is engaged; consequently, the countershaft gears do not run while the car is driven in high gear.

7. Three-Speed Selective Transmission.—The most widely used transmission system for passenger cars and trucks is the three-speed transmission of the selective type. An example of this system is the three-speed transmission shown removed from its casing in Figs. 1 to 5, and it is used in many Northway unit power plants, built for motor car manufacturers. In this model of transmission, as is now the universal practice, the countershaft is mounted below the main shaft. The main shaft consists of the driving part *a*, which carries the pinion *b*, and the driven part *c*, which carries the sliding gears *d* and *e*, and which rotates in a roller bearing mounted within the pinion *b*, and another antifriction bearing at its rear end. The gears *d* and *e* are free to slide lengthwise on the shaft *c*, but are prevented from revolving on it by four splines *f* that fit into corresponding slots in the hubs of the gears. The sliding of the gears is accomplished by the *shifter forks g* and *h*, which are operated by the change-speed lever acting through

the *shifter rods* i and j, respectively. The gears k, l, m, and n in this particular design are separate and are fixed to the counter shaft o, and therefore the countershaft and gears revolve as a unit, the countershaft being carried by two bearings in the transmission housing. In later designs of this same transmission system the four countershaft gears are in one piece and are free to turn on the countershaft, which is firmly fixed at its ends to the transmission housing; hence, with this design the countershaft itself is always stationary. The idler gear p

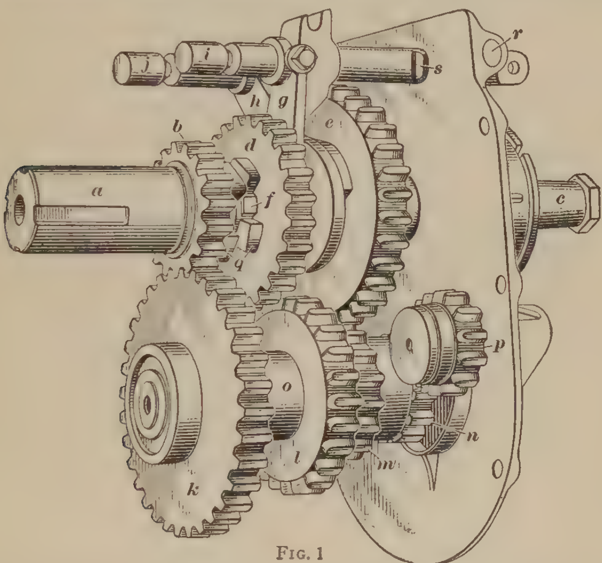


FIG. 1

is carried on a short shaft of its own and is brought into use for obtaining the reverse motion. The pinion b and the gear k are constantly in mesh; hence, the countershaft always revolves when the shaft a is in motion. The driving shaft a is connected to the driven side of the friction clutch and receives its power from the engine, while the driven shaft c is connected to the propeller shaft and drives the differential gear and rear wheels.

8. *First*, or *low*, *speed* is obtained by shifting the gear e by means of the rod j and the fork h until it meshes with the

gear *m* on the countershaft, as shown in Fig. 1. When in this position, the pinion *b* drives the gear *k*, together with the shaft *o* and the pinion *m*; the pinion *m* in turn drives the gear *e* and the shaft *c*, which is connected to the propeller shaft. The gear *k* on the countershaft is larger than the pinion *b*, and therefore rotates at a slower speed. The speed of the pinion *m* is, of course, the same as that of *k*. The gear *e*, which is driven by the pinion *m*, is larger than this pinion and consequently rotates at a slower speed, which is the same as that of the

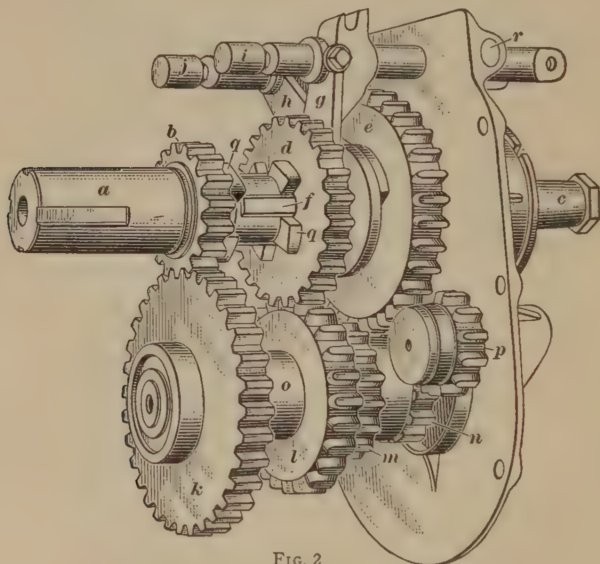


FIG. 2

shaft *c*. There are, therefore, two steps in the reduction of speed between the driving shaft *a* and the driven shaft *c*. The first reduction of speed is between the pinion *b* and the gear *k*, and the second reduction is between the pinion *m* and the gear *e*. Both the driving shaft *a* and the driven shaft *c* rotate in the same direction.

9. *Second,* or *intermediate, speed* is obtained by unmeshing gears *m* and *e* and shifting the gear *d* in mesh with the gear *l* on the countershaft, as shown in Fig. 2. The countershaft is driven at the same speed as before by means of the

pinion *b* and the gear *k*. The gear *l* drives the gear *d* on the main shaft *c*. The gear *l* is the same size as the gear *d*; therefore, the latter gear rotates at the same speed as the gear on the countershaft. There is a reduction of speed from the pinion *b* to the gear *k*, but no reduction or increase from the countershaft to the driven shaft *c*. The result is that the propeller shaft rotates at a slower speed than the driving shaft *a*, but the total speed reduction is not so great as in the low speed position.

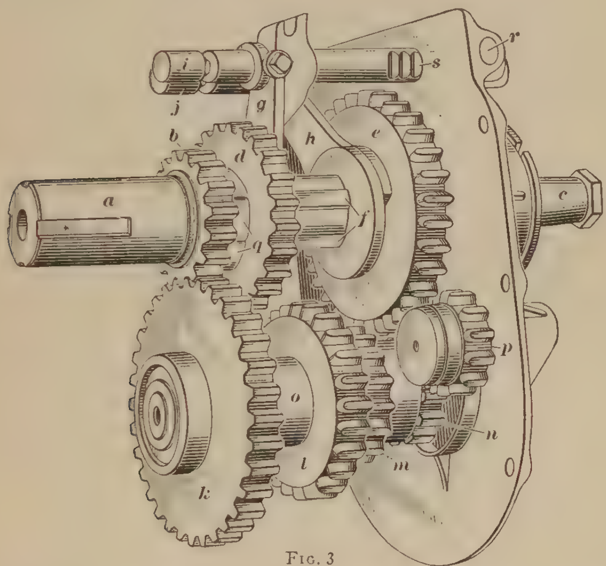


FIG. 3

While the gears *l* and *d* are the same size in the particular transmission illustrated, this is not necessarily the case; sometimes the gear *l* is slightly smaller than the gear *d*, in which case there is a slight speed reduction from the countershaft to the driven shaft *c*. The gear *l* may also be larger than *d*, in which case there is an increase of speed from the countershaft to the driven shaft *c*.

10. In the *third*, or *high*, *speed* position, which is often called the *high-gear* and also the *direct-drive position* of the transmission gearing, the drive is direct from the shaft *a* to

the shaft *c* without going through the intermediary gears on the countershaft. The gears are shown in this position in Fig. 3. This setting is accomplished by sliding the gear *d* forwards so that the clutch jaws *q* at the front end of the gear engage with those on the rear end of the pinion *b*. The transmission of power is now direct from the driving shaft *a* through the jaw clutch to the driven shaft *c*. The pinion *b* is still in mesh with the gear *k*, so that the countershaft revolves, but no power is transmitted through it because the gears *l*, *m*, and *p* run freely without meshing with either gear *d* or *e*.

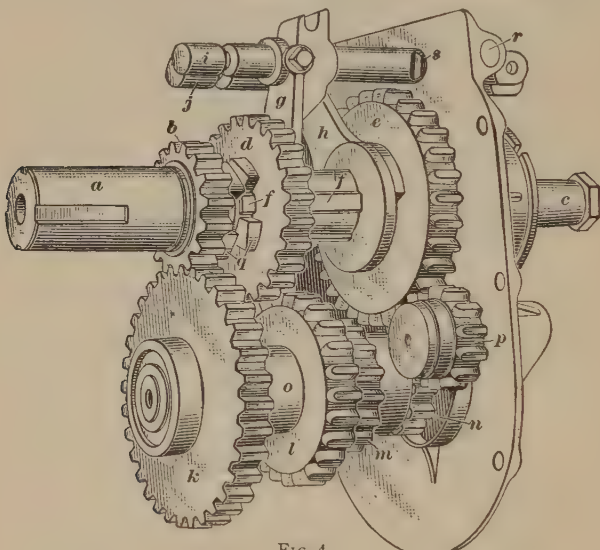


FIG. 4

11. As a four-stroke cycle engine of the kind used in automobile work is not reversible, it is necessary to provide mechanical means for rotating the driving wheels backwards; this is done usually by gearing. The position of the gears in *reverse speed* is shown in Fig. 4. In this speed, the gear *e* is shifted to mesh with the idler pinion *p* and the gear *d* is shifted to a position midway between *k* and *l*. Power is transmitted to the countershaft by means of the pinion *b* and the gear *k*, and through the shaft to the gear *n*, which meshes with the pinion *p*. The gear *n* is small enough in diameter to clear

the gear *c*; it drives the gear *e* by means of the idler *p*. The introduction of this idler causes the gear *e* to revolve in the same direction as the gear *n*, which direction is opposite to that of the shaft *a* and the driving pinion *b*. In all the other cases that have been considered, the driving shaft *a* and the driven shaft *c* rotate in the same direction for forward travel of the car.

12. In the *neutral position*, shown in Fig. 5, the gears are set so that there is no connection whatever between the driv-

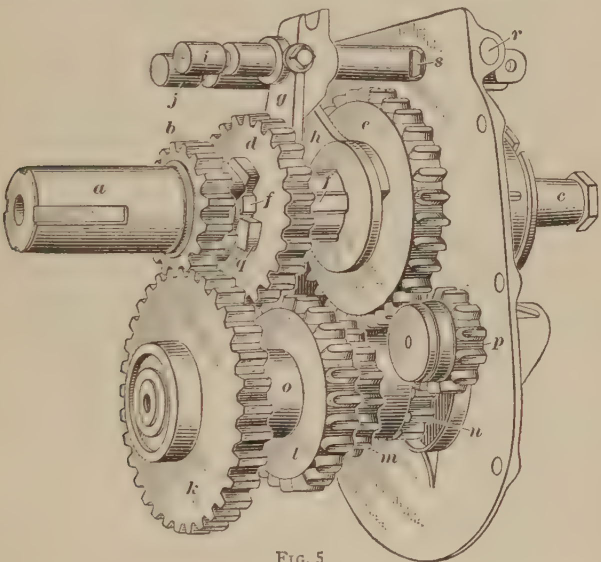


Fig. 5

ing shaft *a* and the driven shaft *c*. The shaft *a* can be driven at full speed by the engine and the shaft *c* will remain stationary in this position. To obtain this setting, the gear *e* is shifted to a position midway between the gears *m* and *p*, and the gear *d* is shifted to a position midway between the gears *k* and *l*. The pinion *b* drives the gear *k* as usual, but there is no connection between the countershaft and the shaft *c*; neither is the jaw clutch *q* engaged. The gears are placed in this position when it is desired to allow the engine to run while the car is at a standstill.

13. In order to secure accurate meshing of the gears as well as to hold them in position, the shifting bars for selective change-speed gears are provided with a locking device. This device usually consists of a spring-operated plunger that drops into a slot in the shifting bar for each position of engagement of the gears. In Figs. 1 to 5, the plunger operating on the shifting bar *i* is located beneath the plug *r* in the end member of the housing and when the gears are shifted to neutral or any other regular position, it drops into a **V** slot *s* in the bar *i*. While these locks are not of sufficient strength to prevent the gears from being shifted by hand, yet they are strong enough to serve the required purpose.

14. Progressive Transmissions.—In the selective transmission just described, the gears can be shifted from any speed to any other speed without going through any intermediate positions. For instance, a change can be made direct from first speed to third or from third to first without passing through second, or it can be made from third to neutral without passing through either first or second. The progressive transmission differs from this, in that in changing from first to third speed or from third to first, it is necessary to pass through second, and in changing from third to neutral, it is also necessary to pass through second speed. In other words, the various positions in the progressive system of transmission must be passed through in a fixed order.

In the actual driving of a car with a selective transmission the gear changes are generally made in regular order, or, in other words, the selective transmission is actually employed progressively nearly all the time. Yet, the buying public has indicated such a strong preference for the selective transmission that the progressive type has gone out of existence, and now is found only occasionally in some old model of car.

15. Four-Speed Selective Change-Speed Mechanism.—Selective change-speed gears giving four speeds forward and one reverse, while at one time quite popular on the higher-priced American cars, are at present used but little on American passenger cars excepting on a few very high-priced

ones, but are quite extensively employed for the heavier trucks. In nearly all modern four-speed transmissions direct drive is on fourth speed. As the principle of operation of almost all four-speed transmissions is the same, the description of a typical one will suffice.

In Fig. 6 is shown a top view, partly in section, of the four-speed selective transmission used in some models of the Locomobile car. This transmission is of the horizontal type,

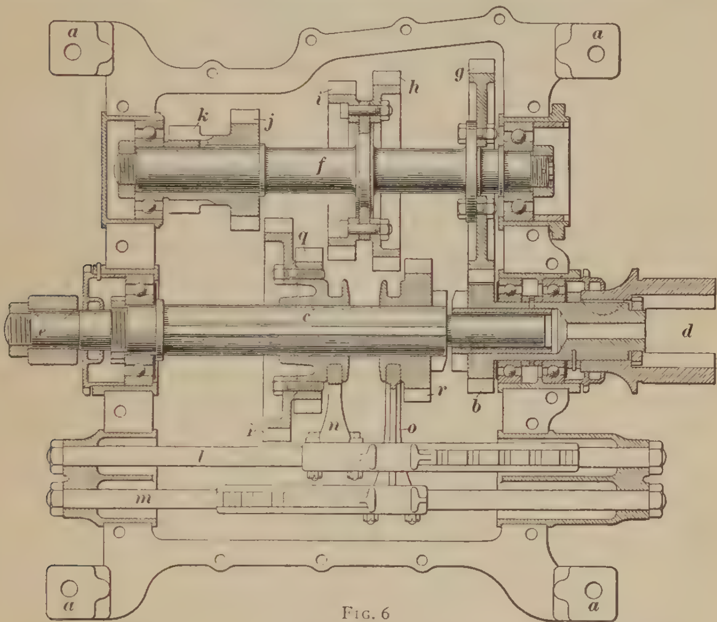


FIG. 6

is a separate unit to the rear of the engine and clutch, and is carried by four brackets *a* on two cross-members of the frame.

As in other sliding gear transmissions, the driving pinion *b* is free from the rear part of the main transmission shaft *c* excepting while in high gear, and receives its power from the engine through the clutch, not shown, and a short driving sleeve or coupling with double universal joints, one at each end. Part of the rear universal joint is shown at *d*. The torque of the engine is transmitted to the propeller shaft, not shown, through a universal joint attached at *e* to the rear of

the main transmission shaft *c*. The countershaft *f* with its five attached gears *g, h, i, j,* and *k* is revolved by the gear *g* which is constantly in mesh with the driving pinion *b*.

In this particular design of a four-speed and reverse transmission, the gears are shifted by two shifter bars *l, m* and shifter forks *n, o*. The shifter bar *l* controls the reverse, and the first and second speeds; the shifter bar *m* controls the third and fourth speeds. The two shifter bars and their forks are operated by the gear change lever, which has a sidewise motion, so it can be engaged with either one of the two shifter bars.

16. The gears are shown in the *neutral position* in Fig. 6, where only the gears *b* and *g* are in mesh. *First speed forward,* or *low speed,* is obtained by sliding the shifter bar *l* to the rear until the gear *p* on the main transmission shaft *c* meshes with the gear *j*. The two halves of the main transmission shaft then turn in the same direction, but the rear part, to which the propeller shaft is attached, turns much slower than the front part. The drive is from the pinion *b* to the large gear *g,* and from the small gear *j* to the large gear *p*. *Second speed forward,* or *first intermediate speed,* is obtained by moving the shifter bar *l* forward until the gear *q* meshes with the countershaft gear *i*. The drive is then from the pinion *b* to the gear *g,* and from the gear *i* to the gear *q* and thence to the propeller shaft. *Third speed forward,* or *second intermediate speed,* is gotten by moving the shifter bar *m* to the rear until the gear *r* meshes with the gear *h*. The drive is then from the pinion *b* to the gear *g* and from the countershaft gear *h* to the gear *r* and thence to the propeller shaft. For *fourth speed,* or *high gear,* the drive is direct, the shifter bar *m* being moved forward until the jaw clutch at the forward end of the gear *r* engages the jaw clutch at the rear end of the driving pinion *b,* thus locking the two halves of the main transmission shaft together. All countershaft gears revolve idly while the car is driven in high gear.

For *reverse,* the shifter bar *l* is moved entirely to the rear until the gear *p* meshes with an idler gear, not shown, which

is constantly in mesh with the gear *k*. The drive is then from the pinion *b* to the gear *g*, and from the gear *k* through the idler gear to the gear *p*. The idler gear forces the rear part of the transmission shaft to turn in a direction opposite to that of the front part.

The shifter bars are locked by spring-actuated plungers dropping into slots cut into the bars.

17. Dodge Brothers Selective Change-Speed Gear. The transmission used in the cars built by Dodge Brothers is of three-speed selective and reverse type, and is so designed that the countershaft gears do not run while the car is driven in high gear. The construction of this transmission, which is used only in the car named, is shown in Fig. 7. The main transmission shaft, as in other sliding-gear transmissions, is divided into two parts; the forward part *a* is called the *clutch shaft* by the maker, and the rear part *b* is called the *sliding-gear shaft*. The countershaft *c* is stationary; the countershaft driving gear *d*, the countershaft low-gear pinion *e*, the reverse gear pinion *f*, and the countershaft intermediate gear *g* are all fastened together, and are free to turn on the countershaft *c*. The clutch shaft has mounted on it the high-speed sliding-gear *h* which when slid forward in the position shown meshes with the countershaft driving gear *d*; the clutch shaft *a* is now unlocked from the sliding-gear shaft *b*. A positive clutch member *i* in the form of an internal gear is rigidly fastened to the forward end of the sliding-gear shaft *b*. When the high-speed sliding gear *h* is slid to the rear, it is unmeshed from the countershaft driving gear *d* and locked to the high-speed internal gear *i*; the two parts *a* and *b* of the main transmission shaft are thus locked together, and the countershaft gears are out of mesh and hence stand still. The sliding-gear shaft *b* carries the low-and-reverse sliding-gear *j* and also the intermediate sliding gear *k*.

18. With the gear-shift lever *l*, Fig. 7, in the position shown, the transmission is in neutral. Hence, with the engine running and the clutch engaged, the high-speed gear *h* meshes with the countershaft driving gear *d*, and therefore all the

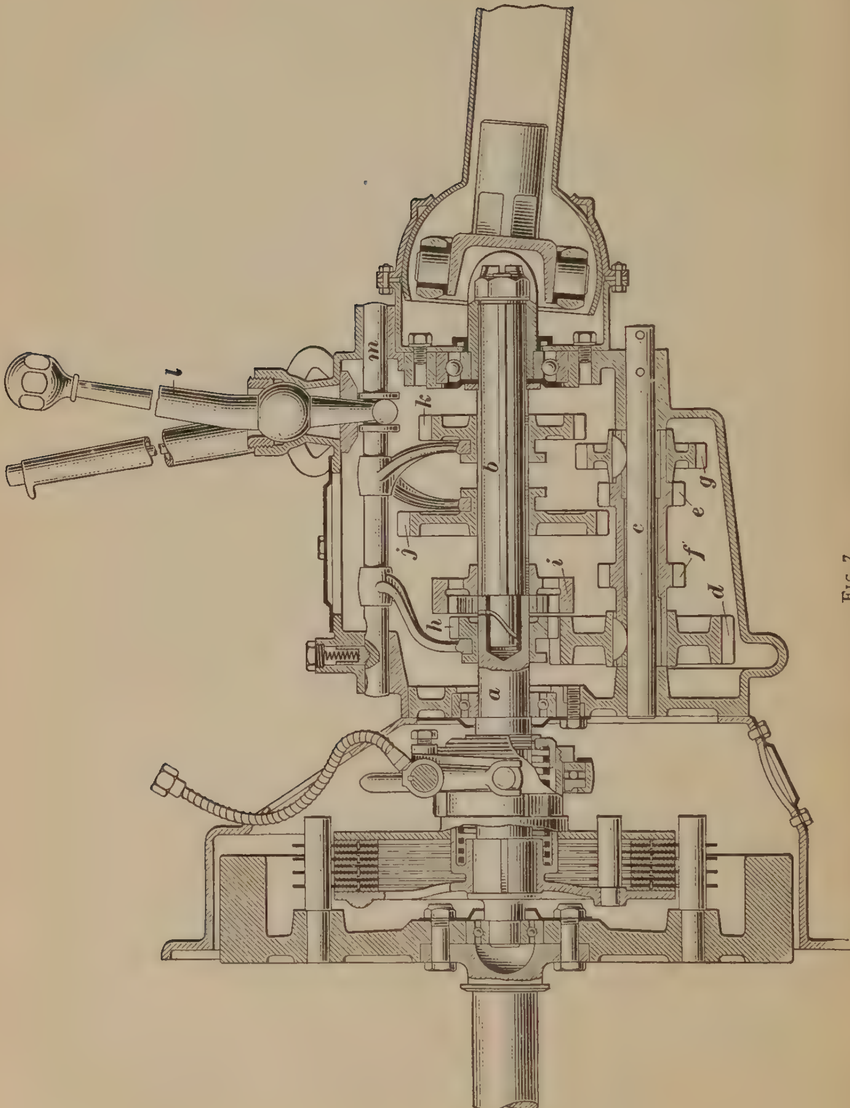


FIG. 7

countershaft gears are running, but as none of these mesh with any of the gears on the sliding-gear shaft *b*, the car is standing still.

To obtain low speed, the gear-shift lever *l* is moved to the left and forward from its neutral position, thereby engaging a shifter bar lying (in the illustration) directly behind the shifter bar *m*, and sliding the low-and-reverse sliding gear *j* into mesh with the countershaft low-speed gear *e*. The torque of the engine is now transmitted through the clutch shaft *a* and high-speed sliding gear *h* to the countershaft driving gear *d*, and thence through the countershaft low-speed pinion *e* and sliding gear *j* to the sliding-gear shaft *b*, and thence through the propeller shaft to the rear axle.

To go into intermediate speed from low speed, the gear-shift lever *l* is first moved to neutral and then to the right and back; this makes it engage the shifter bar *m* and slides the intermediate gear *k* forward into mesh with the countershaft intermediate gear *g*. The drive is now from the gear *h* to the gear *d*, and from the gear *g* to the gear *k*, and thence to the rear axle.

The gear-shift lever *l* is pushed forward to neutral and then to the right and forward to change from intermediate to high gear. This movement of the lever engages it with the shifter bar *m*, slides the intermediate sliding gear *k* out of mesh with the countershaft gear *g*, and slides the high-speed sliding gear *h* out of mesh with the countershaft driving gear *d* and into the high-speed internal gear *i*, thereby locking the clutch shaft *a* and sliding-gear shaft *b* together. The countershaft *c* with its gears is now entirely freed from the clutch shaft *a* and therefore the gears do not turn.

To set the transmission for reverse, the gear-shift lever *l* is moved from neutral to the left and backward. This slides the gear *j* forward into mesh with an idler gear (which cannot be seen in the illustration) that is in constant mesh with the countershaft reverse pinion *f*. The drive is now from the gear *h* to the gear *d*, and from the reverse pinion *f* to the idler gear (not shown), to the gear *j*, and thence to the rear axle. The introduction of the idler gear into the gear-train causes

the sliding-gear shaft *b* to turn in a direction opposite to that of the clutch shaft *a*, thereby causing the car to move backwards.

The various movements of the gear-shift lever here described are peculiar to the Dodge car.

19. Hand Gear-Shifting Mechanism.—On automobiles having the steering gear on the left side, which in American cars is now the almost universal rule, the gear-shift lever is commonly located in the center of the front compartment, just to the right of the driver, and the hand-brake lever is placed to the right of the gear-shift lever. On a few left-hand steering cars, however, both control levers are placed to the left of the driver; once in a while a car is encountered in which the one lever is placed to the left and the other to the right of the driver. With unit power plants in left-hand steering cars the central location of the control levers is popular, because it not only places them in a very handy position, but also permits of their simple and direct mounting on the transmission.

With right-hand drive cars, very few of which are now built in the United States and Canada, although many old cars of this type are still in use, it was the common practice to place both control levers at the right side of the car, with the hand-brake lever on the outside.

While many attempts have been made with sliding-gear transmissions to do away with the hand gear-shift lever, the simplicity of this method of control and the ease with which it can be mastered have caused it to remain firmly in popular favor.

20. Two methods of mounting the gear-shift lever are in use. The older method, still found on many cars, placed the lever in a slotted quadrant, whence the system derived its name of *quadrant gear-shift*. This method, while highly satisfactory as far as operation was concerned, was rather expensive in first cost, owing to the multiplicity and intricacy of parts, and it has been largely superseded by the so-called *ball gear-shift*, which is just as satisfactory but very much cheaper to manufacture.

The method of gear-shift used is independent of the location of the transmission, but the standard location of the gear-shift lever, as previously mentioned, is near the center of the front compartment.

21. Fig. 8 shows a perspective view of part of the chassis of a large six-cylinder American car with left-hand drive and

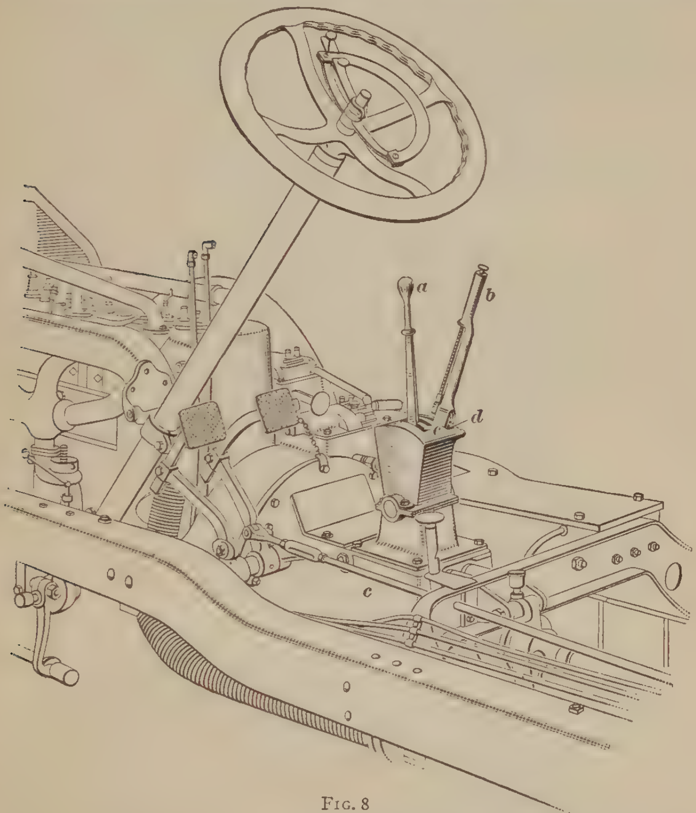


Fig. 8

centrally located quadrant gear-shift. The gear-shifting lever *a* and the emergency-brake lever *b* are located directly over the transmission case *c*. The brake lever *b* operates in a quadrant *d* and is connected by the usual rods to a set of internal brakes on the hubs of the rear wheels. The speed-change lever *a* operates in an **H** quadrant *e*, which permits a sidewise as well

as a forward and backward motion for manipulating the shifter bars. This quadrant rises above the floor board so as to be in plain view of the driver. When the lever is in one slot of the **H** quadrant, it is connected to one of the shifter rods, and when it is moved sidewise to the other slot, it immediately becomes connected to the other rod. Hence, when the lever is moved backwards or forwards in either slot it operates one shifter bar and thus slides the desired gears in mesh and produces the required speed.

The same general principle applies to cars having the control levers on the side, except that, of course, the connection between the hand lever and the shifter rods is more extended.

22. There are two general methods by which the control levers in the sliding change-speed gears of the selective type, and employing an **H** quadrant, are connected to the shifter bars, or rods. The first is by means of a *sliding shaft,* an example of which is shown in part section in Fig. 9, which illustrates the construction used in some Pierce Arrow cars.

In the speed-change mechanism illustrated, the control lever is shown at *a*. Both sliding bars are shown in the end view at *b* and *c,* but only the bar *c* appears in the side view, because *b* lies immediately back of it. The speed-control lever *a* is fastened to a tubular shaft *d* that carries an arm *e* at the end next to the shifting bars. This arm is shown in the side view in engagement with the shifter bar *c*. The tubular shaft *d* can be slid toward the right from the position shown in the end view, so as to disengage the arm *e* from the shifter bar *b* and bring it into engagement with the shifter bar *c,* or as shown in the side view. The control lever *a* moves in slots in a quadrant *f*. These slots are so placed that the lever *a* can be pushed forwards or drawn back only when it is in full engagement with one of the shifter bars. The extent of the movement of the control lever is restricted by the length of the slots in the quadrant. Thus, when the lever is thrown either full forwards or back, the gears with which it is then in connection are set to the proper position for the corresponding speed, and the shifting bars are held in these positions by the pawls or plungers.

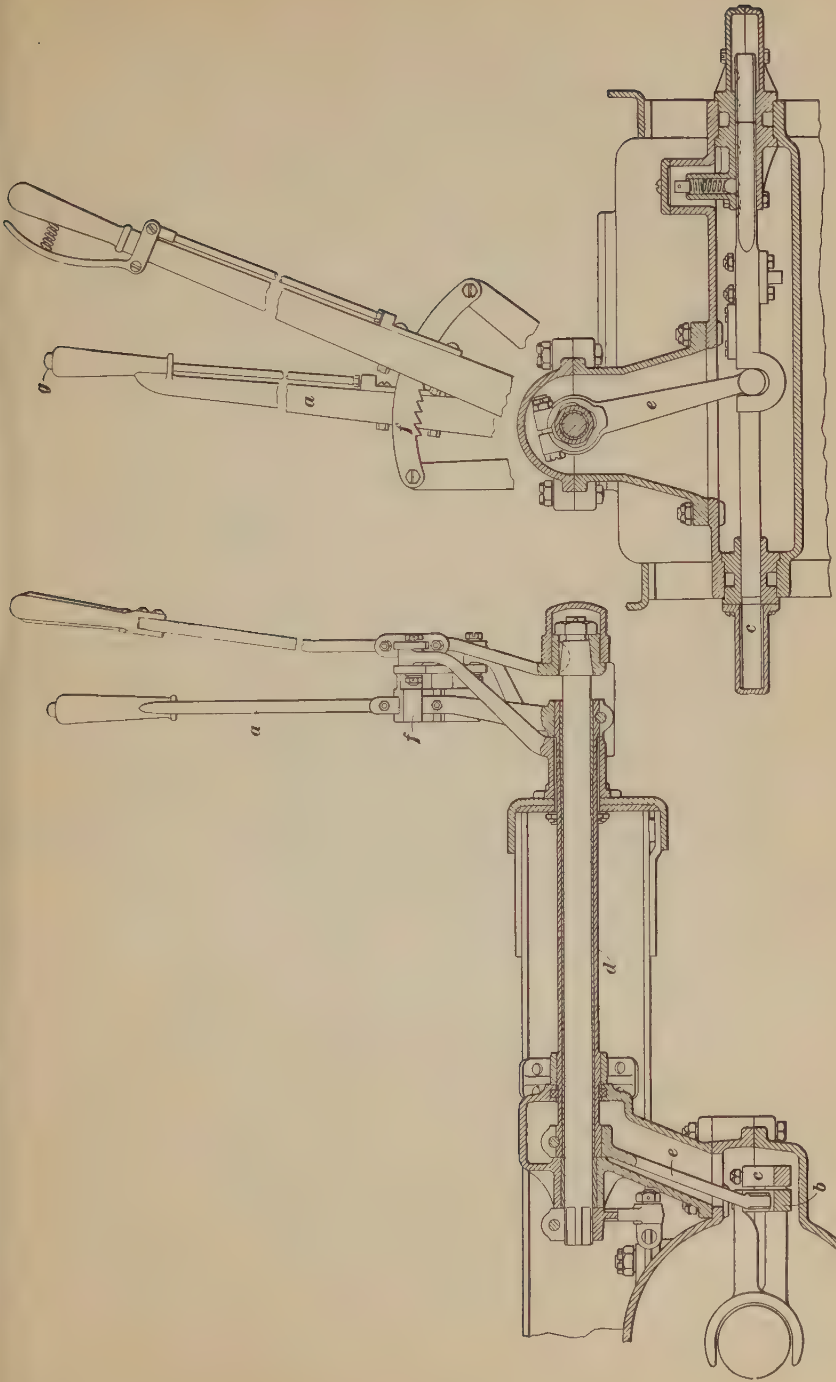


FIG. 9

There are two slots in the quadrant in which the control lever moves when shifting the gears. When the lever is near the middle of either slot, the gears are in neutral position. The two slots are connected by an opening corresponding to the neutral position of the lever, so that the lever can be shifted sidewise to engage either of the sliding bars when the gears are in neutral position. The two slots and the opening between them together appear much like the letter **H**. One of the slots is elongated and is provided with a stop that ordinarily prevents the control lever from going more than the proper distance to set the gears on slow speed forwards. In order to bring the control lever to the reverse position, it is necessary to press down the push button *g* at the top of the control lever. This allows the lever to move far enough to bring the reverse gears into engagement. The stop mentioned is useful, as it prevents the reverse gears from being thrown into action accidentally when shifting the gears during forward travel of the car, but is used only in this make of automobile.

The sliding-shaft method of engaging the gear-shift lever with the shifter bars has been used in many automobiles.

23. The second method of connecting the control lever with the gears when an **H** quadrant is used, employs what is called a *swinging lever*. In this the lever is pivoted near its lower end, and can be made to engage projections on arms connected to the shifter bars. There is one arm on each side of the lever, and by swinging the lever to one side or the other one of the arms is engaged by the lever and therefore moves with it. This method was largely employed for many years, but is now obsolete.

24. Most sliding-gear transmissions in American cars built during the last few years employ the *ball shift*. An example of a ball-shift mounting for the gear-shift lever is presented in Fig. 10, which illustrates part of the unit power plant of an eight-cylinder Cadillac car. As is the most common practice with unit power plants, the gear-shift lever *a* is mounted directly on top of the transmission cover *b*. A large ball *c* is

formed on the lever *a* near its lower end, and fits into a corresponding socket, thus permitting the lever to swing in all directions. As in all three-speed sliding-gear transmissions, there are two shifter bars, of which only one *d* can be seen, the view of the second one being hidden by *d*. When the gear-

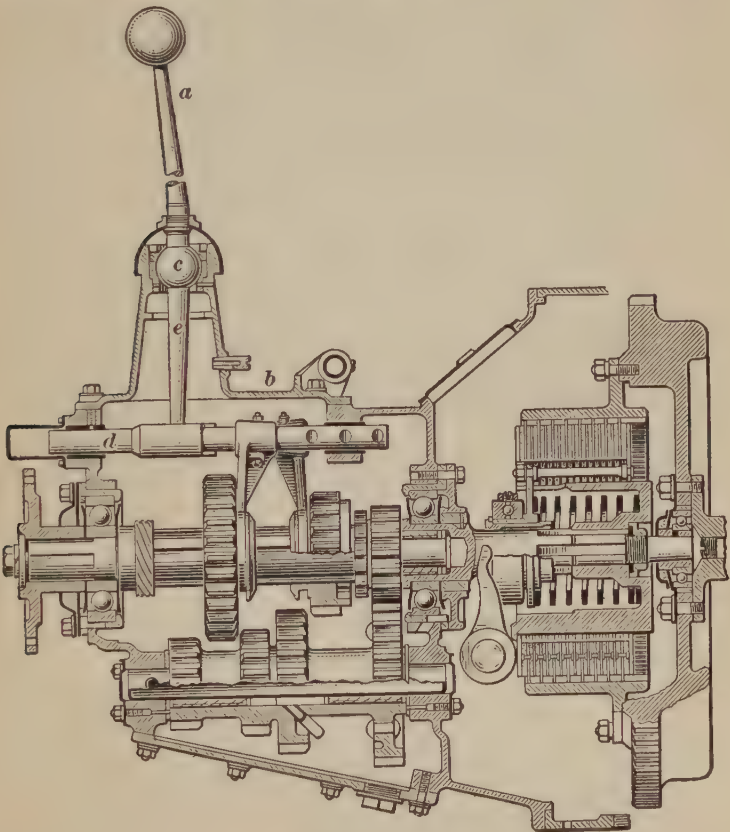


FIG. 10

shift lever *a* is in neutral, swinging its top to the left makes its bottom end *e* engage the right shifter bar *d*; and swinging the top of the lever to the right causes it to engage the second shifter bar.

In some cases the lower end of the gear-shift lever of a ball shift is forked, and this fork hooks over a pin carried by each

shifter bar. In other cases the lower end of the gear-shift lever has a ball formed on it, or is similarly rounded over, and engages a slot of each shifter bar. In any case examination of the actual transmission at once discloses the method used to engage the lever with the shifter bars.

25. Gear-Shift Lever Movements.—In designing a selective sliding-gear transmission, the general arrangement of the several gear sets is variable, and therefore the gear-shift lever may have to be placed in different positions for the same gear in different cars. On account of such differences of position it is very awkward for an operator who is familiar with one make and model of car to drive another car on which the

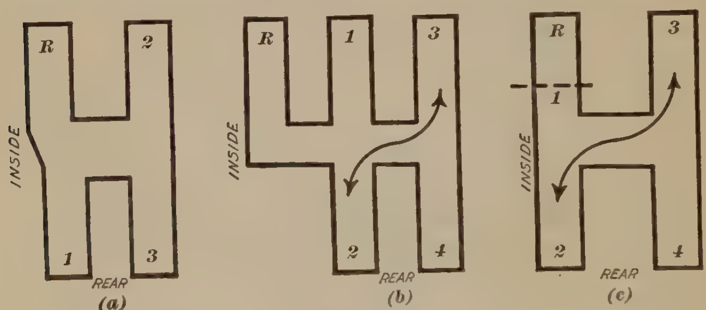


FIG. 11

gear positions are arranged differently. Therefore, the Society of Automotive Engineers has, after proper investigation, recommended certain standard arrangements of the gear-shift lever positions for both three-speed and four-speed transmissions, and these standard arrangements are not only very widely used at present, but they are gradually supplanting all other arrangements.

The three recommended standard gear-shift positions, for three-speed and four-speed selective transmissions are shown in Fig. 11. For the sake of clearness, a slotted quadrant is shown in each case; it will be understood that if a ball shift is employed, as a general rule there is no quadrant fitted. In many cases the quadrant, or the footboard, through which the gear-shift lever projects, is plainly marked with letters or

numerals to indicate the gear. Thus, the letter *R* stands for reverse; the letter *L* for low speed forward; the letter *I* for intermediate speed forward, and the letter *H* for high speed forward, etc. As a general rule, when numerals are used, the higher number indicates the higher speed.

Referring to Fig. 11, in (*a*) is seen the arrangement for the three-speed gears, the numbers representing the positions of the lever for the several speeds forward and the letter *R* indicating the reverse position. In (*b*) is presented a quadrant for a four-speed gear-set. View (*c*) shows the preferred arrangement of a quadrant for a four-speed gear-set having two shifter bars, the sliding gears for reverse, first speed, and

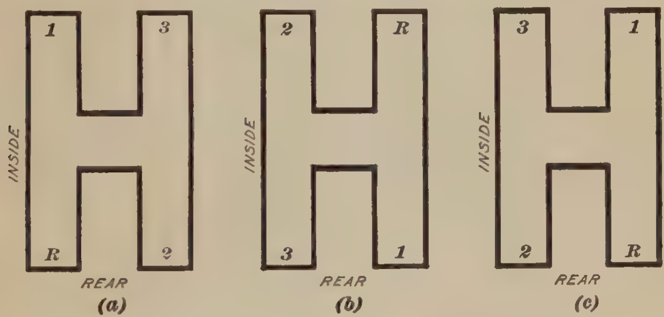


FIG. 12

second speed being operated by the same bar. A gear-set of this type is not truly selective, but is a combination selective and progressive gear-set, since in order to change to the reverse position, it is necessary to go through the first-speed position from any other setting. The dotted line indicates a stop-block that prevents the lever from being accidentally thrown into the reverse position. With this type of quadrant, a latch must be withdrawn before the gears can be shifted to reverse. The word *inside* represents the side next to the driver, for left-hand drive and center control, or right-hand drive and right-hand control, and the word *rear* indicates the rear of the car.

26. Non-standard gear-shift lever positions, for three-speed transmissions, which have been and are still widely used,

are shown in Fig. 12. At (*a*) the gear-shift lever positions of the Dodge car, already explained in Arts. **17** and **18**, are shown; at (*b*) the positions employed in many Buick and Franklin cars are illustrated. Many models of the Oakland and

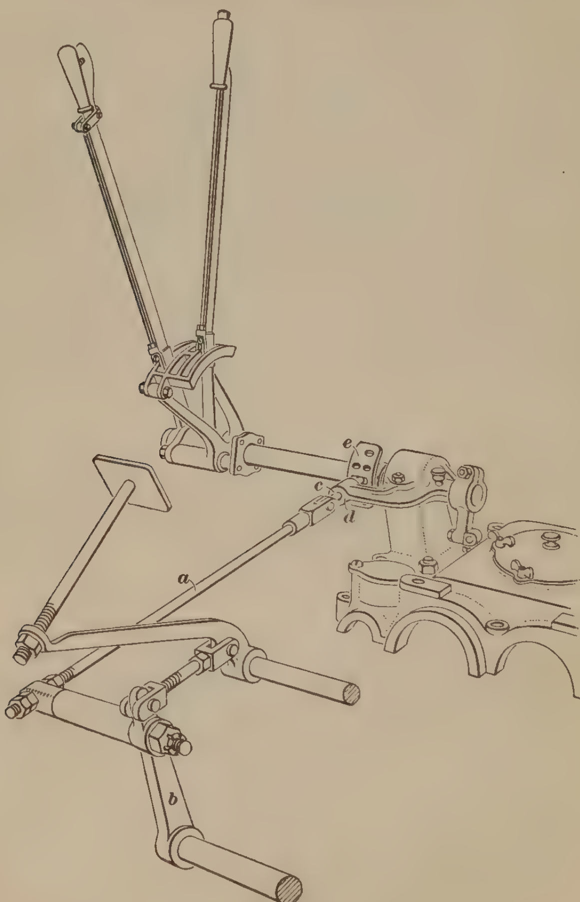


Fig. 13

early Hupmobile cars have the gear-shift lever positions indicated at (*c*). The outlines drawn around the positions in Fig. 12 do not necessarily indicate that a quadrant is used, but rather show the limits of movement of the gear-shift lever.

27. Transmission and Clutch Interlock.—In some cars there is incorporated a device by means of which the speed-change gears and the clutch-actuating mechanism are interlocked in such a manner that it is impossible to shift the gears without first releasing the clutch, or to engage the clutch unless the gears are in full mesh. With a gear-shifting mechanism provided with such an interlock, the gears are shifted in exactly the same manner as if no interlocking device were fitted. The interlock acts without any special attention from the operator of the car. The advantage of this arrangement is that it prevents injury to the gears from shifting them with the clutch engaged.

The interlocking arrangement incorporated in some models of the Pierce Arrow car is shown in perspective in Fig. 13. One end of a rod *a* is attached to the arm *b* of the brake-operating mechanism and the other end carries a plunger *c* that is moved forwards or backwards in a guide *d* when the clutch pedal is depressed or released. A sector *e* is carried on the control-lever shaft and it is provided with holes in its surface into which the plunger *c* engages when the control lever is in any of the various speed positions and the clutch pedal is released. When in the neutral position, the plunger engages in a slot running across the face of the sector and parallel with the shaft. By this arrangement the control-lever shaft cannot be rotated, and hence, the gears cannot be shifted unless the clutch pedal is depressed and the plunger *c* withdrawn from the hole or slot in which it is engaged at the moment. The clutch cannot be fully engaged unless the gears are fully meshed and the sector is in one of the positions that will permit the plunger to engage with a hole or the slot and thus allow the clutch spring to act.

PLANETARY CHANGE-SPEED GEARS

28. Definitions.—In the planetary type of change-speed gears, an arrangement of gears, known as an *epicyclic train*, is employed for producing the various speeds. An epicyclic-gear train is a combination of gears in which one or several

gears turn on an axis that itself moves about a fixed axis. In mechanics an axis is the straight line around which a turning body revolves. On account of the similarity of this motion to that of the planets around the sun, it is commonly called the *sun-and-planet motion*. In a gear-set of this type, the driving member may be a ring or wheel carrying the movable axis or axes, and the driven member a gear on the fixed axis, or the arrangement may be reversed.

The epicyclic-gear train now used for change-speed gears in automotive work, that is, for passenger cars, trucks, and tractors, is made up entirely of spur gears, and is therefore known as the *all-spur type*.

29. Principle of Operation.—A simple epicyclic-gear train of the all-spur type is shown diagrammatically in Fig. 14.

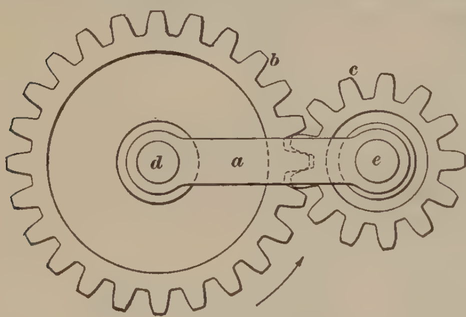


Fig. 14

An arm *a* joins the two gears *b* and *c* and holds them in mesh. The axis *d* of the gear *b* is fixed, but the arm *a* is free to revolve around this axis and carry the gear *c* bodily with it. Suppose that the gear *b* is held stationary and the arm *a* is turned in the direction of the arrow about the axis *d*. The gear *c* is then carried bodily around the axis *d* and at the same time it rolls on the gear *b* and turns on its own axis *e*.

30. By adding more gears to the simple train shown in Fig. 14, a combination can be obtained whereby the driven member may be made to rotate at different speeds by holding different gears stationary. Fig. 15 shows the principle involved in the all-spur planetary transmission, indicating the manner in which low speed, high speed, and reverse are obtained. The gears *a* and *b* have a common axis *c*, but are free to turn independently of each other. Meshing with *a* and *b* are three pairs

of gears consisting of two gears each, *d* and *e*, that are fixed to each other and revolve together. The gears *d* and *e* are mounted on a ring *f* that is free to move; hence, these gears not only turn on their own axes, or centers, but by turning the ring *f* they can be carried bodily around the gears *a* and *b*.

While a perfect planetary motion can be obtained by using only one pair of gears *d*, *e*, to prevent excessive vibration of the mechanism caused by being out of balance, several sets of

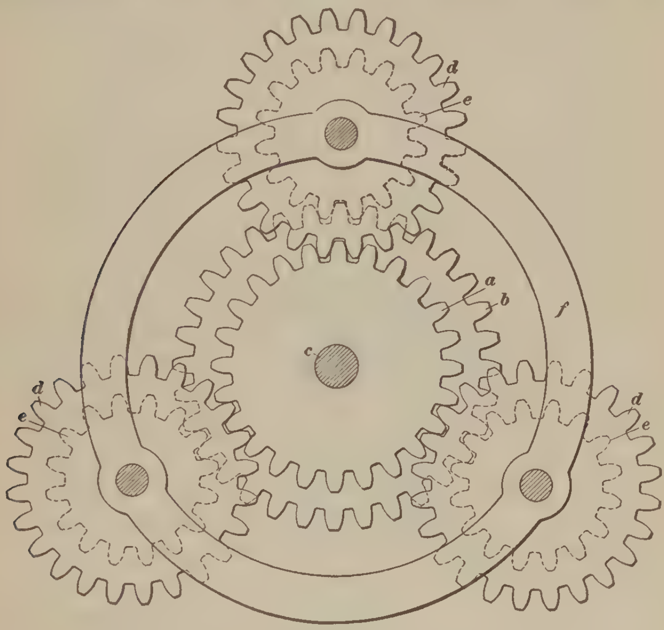


FIG. 15

pairs of gears, disposed at equal angles between them, must be used in practice. In this case three sets of gears *d*, *e* are shown, which is in accordance with usual practice.

31. To get a reverse motion of the gear *a*, Fig. 15, that is, to make it turn counter-clockwise when the ring *f* is turned clockwise, the gear *b* is held stationary in any convenient manner. Now let the ring *f* be turned clockwise. The gears *e* have two motions: they travel bodily around the gear *b* in a

clockwise direction and also turn clockwise on their own axes, because they roll on the gear *b*. As previously stated, the gears *d, e* of each pair are fastened together and therefore turn as units. It will be apparent that if the gears *d* and *e* were of the same size, the gears *a* and *b* would have to be the same size to mesh with *d* and *e*. But if this were the case, turning of the ring *f* would have no effect at all upon the gear *a*, which would simply be stationary. Therefore, to obtain a rotary motion of the gear *a*, this gear must differ in size from *b*, and hence, to have *d* and *a* mesh, the gear *d* must differ in size from *e*. Suppose the case is as shown in Fig. 15, where *d* is larger than *e*, and *a* smaller than *b*. Then, if the ring *f* is turned clockwise, the gears *d* and *e* also turn clockwise through equal angles, but as *d* is larger than *e*, a tooth of *d* passes through a greater distance than a tooth of *e*; in other words, the teeth of the gear *d* have a greater linear speed than the teeth of the gear *e*. This in turn means that the gear *a* is forced to turn in respect to the gear *b*, which is stationary. But, as the gears *d* and *a* mesh, the gear *a* must turn counter-clockwise when the gear *d* turns clockwise, and as this occurs when the ring *f* is turned clockwise, the rotation of the gear *a* is reversed in respect to the ring *f*.

32. To obtain a slow forward speed by means of the reverted-gear train shown in Fig. 15, the gear *a* is held stationary by any convenient means; this causes the gear *b* to turn in the same direction as the ring *f* is turned, but at a much slower speed. Let the ring *f* be turned clockwise and the gears *d* and *e* will also turn clockwise, and the gear *b* turns counter-clockwise with respect to the gears *d* and *e*. But the axes of three sets of gears *d* and *e* are also moving clockwise on account of their being fastened to the ring *f*, and, therefore, the gear *b* is moved faster in a clockwise course than it turns counter-clockwise; the actual or net clockwise motion of the gear *b* will then be equal to the difference between its clockwise and counter-clockwise motions. From the foregoing statements it follows that the gear *b* actually turns clockwise at a much slower speed than the ring *f*.

If the gears *d* and *e* are of the same size, and the gears *a* and *b* are also equal, there can be no motion of the gear *b* when the ring *f* is revolved; the gear *b* will simply remain stationary with respect to the gear *a*. This proves the necessity of the various gears having different sizes.

33. In all automotive work where a planetary transmission is employed, high speed forward is obtained by locking all gears together. If this is done, as in Fig. 15, the whole system of gearing will rotate as a unit around the shaft *c*, and none of the gears will revolve in relation to each other.

34. Ford Two-Speed Planetary Transmission. The representative planetary transmission is the Ford all-spur system, used in the model T car, which is designed to give two speeds forwards and a reverse. The manner in which the reverted epicyclic-gear train is applied to this gear-set is shown in Figs. 16 and 17. Fig. 16 is an external view and part section of the transmission in its case, and Fig. 17 a sectional view of the system removed from its case. Like parts in the two illustrations as far as possible are lettered the same.

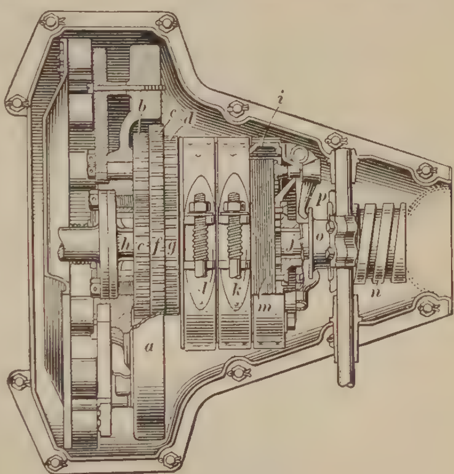


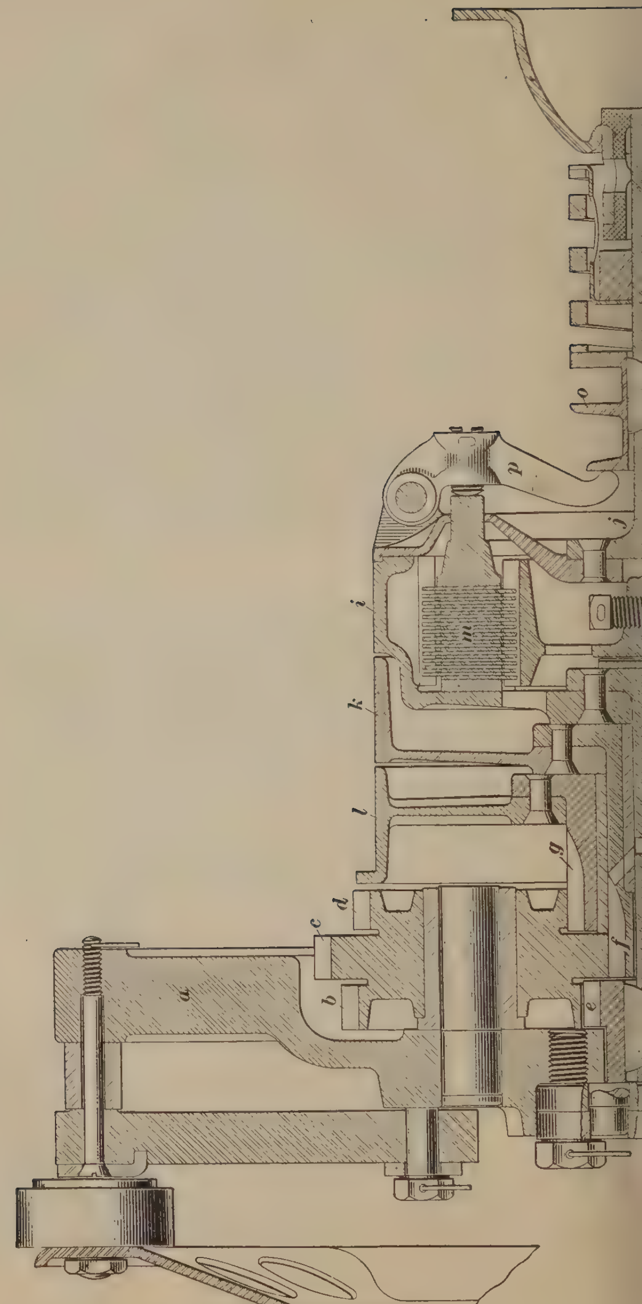
Fig. 16

The driving member in this case is the engine flywheel *a*. The flywheel carries on studs three clusters of three gears each, *b*, *c*, *d*, which, at first, were made separately and then riveted together, but of late years they have been made in one piece. These three groups of gears are spaced 120 degrees apart, and are free to turn on studs fastened rigidly to the flywheel. The three gears of each group mesh with three other gears *e*, *f*,

and g, that are supported by an extension h of the crank-shaft, as seen in Fig. 17. The gear e is the driven member and is keyed to a sleeve that forms the hub of the clutch drum i. The drum i is joined to the propeller shaft by means of a second sleeve, or hollow shaft, j and a universal joint; hence, when the gear e is revolved, the propeller shaft revolves with it. The gear f is formed on the hub of the drum k, and the gear g on the hub of the drum l. Each drum is surrounded by a band as shown in Fig. 16, by means of which it may be prevented from rotating. The band surrounding the drum i is utilized simply as a brake band for slowing down or stopping the car, while the bands surrounding the drums k and l are brought into use for obtaining a reverse or slow speed. The clutch drum contains the multiple-disk clutch m, by means of which the drum and engine-shaft extension h can be connected when it is desired to drive the propeller shaft at crank-shaft speed.

35. To obtain low gear, the middle drum k, Figs. 16 and 17, is held from rotating by tightening a brake band on it; in the actual car this is done by pushing a pedal forward. As the gear f is fastened to the drum k, this gear is held stationary. The holding of the middle drum k automatically releases the high-speed clutch m, and therefore the crank-shaft extension h and the propeller shaft are now free to turn independently. When the engine runs, the flywheel carries the triple gears b, c, d around with it, the three gears c rolling on the gear f; therefore, the three sets of triple gears turn on their own axes, that is, on their studs, and also turn with the flywheel. Hence the gear e, fastened to the drum i turns on the crank-shaft extension h and, therefore, the drum i also turns, carrying around with it the sleeve j which is fastened to the drum i. This sleeve j in turn drives the propeller shaft, which is now running slower than the crank-shaft extension h, but in the same direction; slow speed forward is thus obtained.

36. To obtain reverse in the T model Ford car the reverse pedal is pushed forward; this tightens a brake band onto the drum l, Figs. 16 and 17, and keeps it from turning. While in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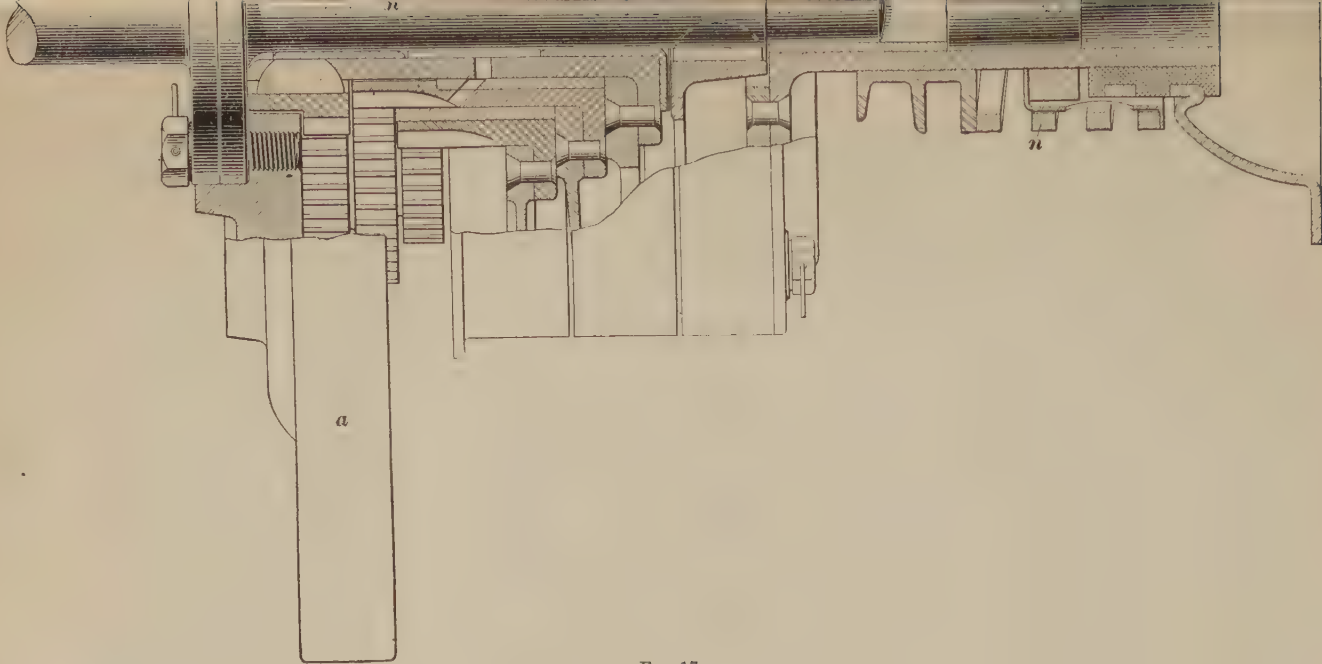


Fig. 17

reverse the high-speed clutch *m* is released and therefore the crank-shaft extension *h* and propeller shaft are free to turn independently. As the gear *g* is part of the drum *l*, holding this drum also holds the gear *g*; when in reverse the drum *k* and hence the gear *f* are unlocked. Rotation of the flywheel causes the triple gears *b*, *c*, *d* to turn on their axes and to rotate with the flywheel, because the gears *d* roll on the stationary gear *g*. Then, the gears *b* drive the gear *e* and therefore the drum *i* and the sleeve *j* and hence the propeller shaft in the direction opposite to that in which the flywheel turns, or, in other words, the transmission is in reverse.

37. High speed forward is obtained in the Ford transmission by engaging the multiple-disk clutch *m*, Figs. 16 and 17. In this way the crank-shaft extension *h* and the clutch drum *i* are locked together, and drive the propeller shaft at the same speed the engine shaft revolves. The clutch, like those used with sliding-gear transmissions, is normally held in engagement; its plates are pressed together by the clutch spring *n* which surrounds the sleeve *j* and acts upon the plates by means of the sliding sleeve *o* and three levers *p*.

In the actual car there are three pedals and a single hand lever, for operating the transmission and the brakes. The left pedal when pushed forwards gives low speed; when released entirely it engages the clutch and thus gives high speed, and when pushed forward to its middle position it places the transmission in neutral, the high-speed clutch then being disengaged.

INDIVIDUAL CLUTCH SPUR-GEAR TRANSMISSION

38. While the sliding-gear type of transmission is very widely used, and gives full satisfaction when operated by a driver who has learned by experience to shift gears properly, yet there are some objections to its use in very heavy trucks, where heavy loads are carried and the driving is done by an operator selected chiefly for his physical strength. Under such conditions the gear-teeth, which are comparatively small, are liable to receive severe shocks and be broken during gear changes. Therefore, several attempts have been made to

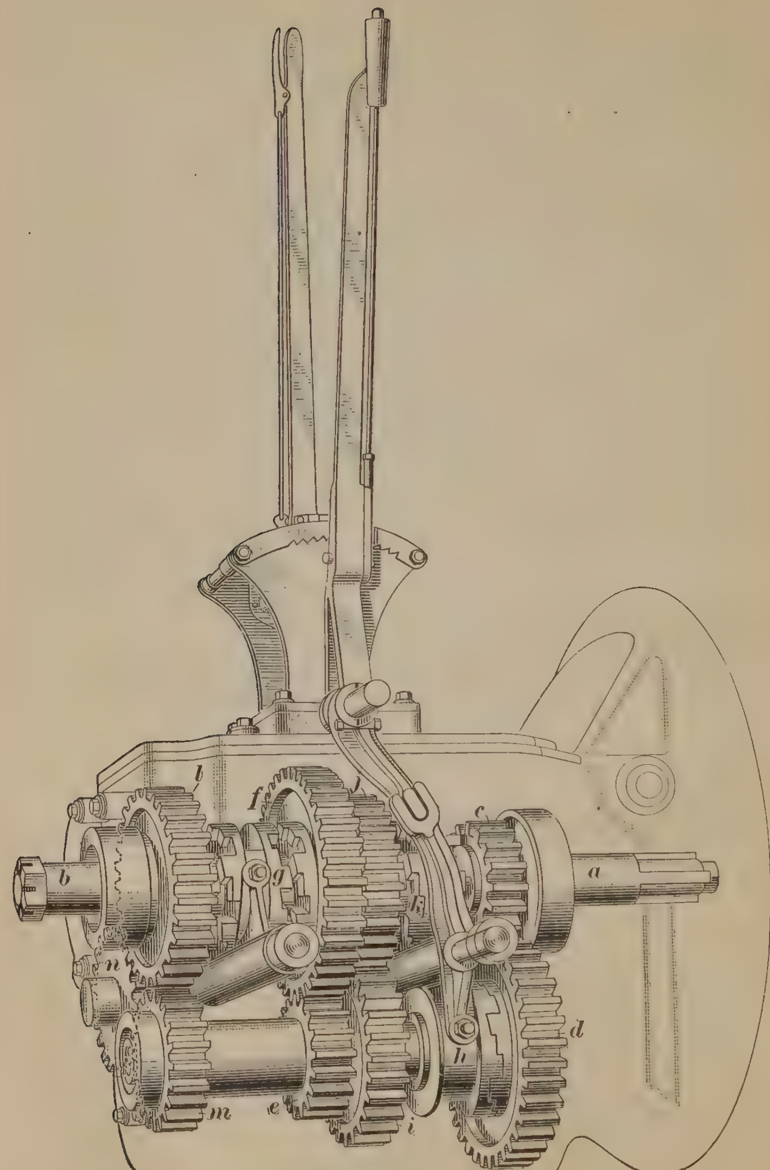


Fig. 18

design and use transmissions in which all the gears are constantly in mesh, and where the changes from one gear ratio to another one, or to reverse, are effected by individual clutches of sturdy construction. The use of individual friction clutches for this purpose has proved a complete failure in practical work, owing chiefly to the mechanical limitations to their size. Positive clutches of the jaw type have proved highly successful, however, for individual clutch transmission.

39. The *Cotta transmissions,* which are built for truck and tractor use, with two, three, and four forward speeds, are of the individual jaw-clutch type. One of the three-speed Cotta transmissions for a unit power plant is illustrated in Fig. 18; the case surrounding it, for the sake of clearness, is assumed to be transparent. As in all standard spur-gear transmissions, the main transmission shaft is divided into two parts, of which the forward part *a* is connected to the clutch of the engine. The rear part *b* of the main transmission shaft is locked to the forward part *a* when the transmission is in high gear.

The gears *c, d, e,* and *f* form the low-speed forward gear train. To engage this speed from neutral, where all of the jaw clutches are disengaged, the jaw clutches *g* and *h* are moved into engagement with the jaws formed on the gears *f* and *d*; the gear *c* is at all times fastened rigidly to the shaft *a*. The drive now is from the shaft *a* and the gear *c* to the gears *d* and *e,* which turn at the same speed, to the gear *f* and shaft *b,* the gear *f* being clutched to the shaft *b* by the clutch *g*. For second speed forward the gears *c* and *d,* and *i* and *j* are used. To go into second speed from first, the gear *f* is unclutched from the shaft *b* and the gear *j* clutched to this shaft instead by moving the clutch *k* to the rear. The drive now is from the gear *c* to the gears *d* and *i,* which turn at the same speed, to the gear *j* and the shaft *b*. To go into high gear, the clutch *k* is moved forward and the clutch *h* is simultaneously disengaged from the gear *d*. This locks together the two halves *a* and *b* of the main transmission shaft, all transmission gears now being idle. To go into neutral, whatever clutches happen to be engaged are withdrawn. To go into

reverse from neutral, the clutch *h* is shifted forward and the clutch *g* to the rear, to engage the large reverse gear *l*. The drive now is from the shaft *a* to the gear *c* to the gears *d* and *m*, which turn at the same speed, to an idler gear *n* meshing both with *l* and *m*, and thence to the gear *l* and shaft *b*. As in all other spur-gear transmissions the use of an idler gear in the reverse gear train causes the shaft *b* to turn opposite to the shaft *a*.

FRICTION-GEAR TRANSMISSION

40. For changing the speed of the car in relation to the engine speed, the **friction-gear transmission** makes use of a friction disk and a friction wheel which run at right angles to each other. The friction units are so arranged that a separate friction clutch is unnecessary; the engine can be disconnected from the transmission mechanism by withdrawing the disk from the wheel and allowing the disk to run idly. With this change speed-gear, an infinite number of speeds may be obtained by varying the point of contact between the friction wheel and the disk.

While the friction-gear transmission has some advantages, it has never met with the favor of the buying public, and makers of cars fitted with such transmissions have either changed their product to something more salable or the makers have gone entirely out of business. Hence, a brief general description will be sufficient to give an insight into the arrangement of the mechanism.

41. The Carter car, no longer made, was one of the most successful and widely used examples of an automobile with a friction transmission. The general arrangement of this device is shown in Fig. 19. In this transmission, the friction disk *a*, which is driven by the engine, drives the fiber-faced wheel *b*, which, in turn, propels the rear axle by means of a chain that is enclosed in an oil-tight case *c*. The disk *a* is connected to the engine by a short shaft containing a sliding connection that allows the disk to be engaged with the friction wheel by a pressure on the pedal *d*. The wheel *b* is mounted on a trans-

verse shaft e in such a manner that it can be made to move across the face of the disk a from one side to the other and to drive the shaft e in any position. The friction wheel b is shifted by a bell-crank f connected to a crank-arm g of the control lever h. The bell-crank is pivoted to a bracket i and carries a drag link j, through which the wheel is moved.

As the linear speed of points at different distances from the center of the disk a varies from zero at the center to a maximum at the periphery, or outer edge, the rotative speed of the friction wheel depends on its distance from the center of

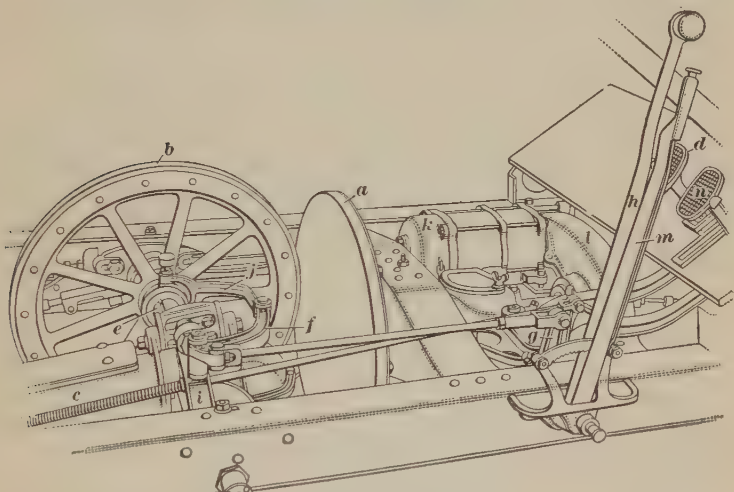


FIG. 19

the disk. Thus, to obtain a slow speed, the friction wheel b is shifted toward the center of the disk a by a rearward movement of the control lever h, and to obtain higher speeds it is shifted toward the periphery by a forward movement of the lever. To obtain a reverse, the friction wheel is shifted past the center of the disk a, when the direction of rotation of the wheel, and hence of the driving wheels of the car, is reversed. The neutral position is obtained by simply releasing the pedal, when the disk is free to revolve without transmitting motion to the friction wheel. In this car the action of the pedal d is opposite to that of the clutch pedal in the

ordinary sliding-gear change-speed mechanism. Depressing the pedal *d* engages the friction disk and wheel and starts the car. A locking device is provided by means of which the friction surfaces can be held in contact without keeping the foot on the pedal.

The electric starting motor, which furnishes power for cranking the engine, is shown at *k*, Fig. 19. This motor is connected to the shaft running from the engine to the friction disk by a silent chain that is encased in an oil-tight case *l*. The emergency-brake lever is shown at *m* and the service-brake pedal at *n*. These are operated the same as on any other car.

ENTZ ELECTRIC TRANSMISSION

42. Numerous attempts have been made by various engineers to obtain a great torque range at the driving wheels of automotive vehicles propelled by internal-combustion engines without the use of a transmission containing gears. At the same time, it has been the aim to do away with the noise associated with the use of gears running at high speeds under heavy loads, and the friction losses incidental to their use.

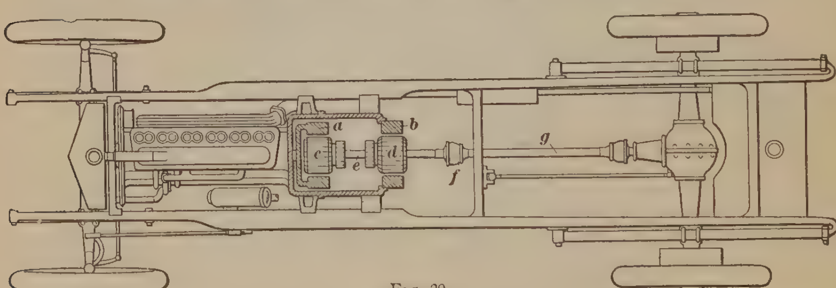


FIG. 20

The design of a transmission mechanism without gears that has been used is known as the *Entz electric transmission*, and has been incorporated in the Owen Magnetic cars, which have been built by a few concerns catering to a select trade. The details of the design vary in the different cars, but the general principles are common to all. Therefore, only principles will be explained here.

The chassis of one make of an Owen Magnetic car is shown in diagrammatic form in Fig. 20. The transmission consists chiefly of an electric generator having a revolving field *a* which serves as the flywheel of the engine, and an electric motor having a stationary field *b*. Both the generator armature *c* and motor armature *d* are fastened to the armature shaft *e*, which shaft, through a universal joint *f*, is connected to the propeller shaft *g*. There is no mechanical connection between the engine and the driving wheels of the car at any time. A number of resistance coils for regulating the electric current, and a controller switch having its handle located at the top of the steering gear, form a part of the electric transmission.

To crank the engine, storage-battery current is turned into the generator, which, therefore, acts as a motor and spins the engine to get it started. As soon as the engine fires, the controller switch is either put to neutral, where all circuits are open, so that no current is being produced by the generator, or it is put to the charging position, where current generated passes to the storage battery to charge it. To start the car when the engine is running, the controller switch is put into the first-speed position. As the car is at rest, both armatures are also standing still, but because the generator field is revolved by the engine, current is produced by the generator and sent through the motor back to the generator. It will be understood that the generator field in rotating tends to revolve the generator armature, and that the current generated on account of the difference in speed between the generator field and armature shaft, tends to revolve the motor armature. In consequence the armature shaft is revolved and the car begins to move. Under these conditions the generator gives its greatest current output and the largest torque is exerted at the motor armature, and therefore at the driving wheels. Speed changes of the car, within the range given by the controller-switch position, are now effected by throttle and spark control of the engine. To lessen the torque at the driving wheels, that is, to go into a higher gear, as it may be called, the controller switch is moved step by step to its high-gear position, and the car is driven in this position most of the time. When

the controller switch is in its high-gear position, the electrical connections are such that the generator field exerts its greatest torque on the generator armature. At the same time, the motor has been transformed into a differentially compounded generator, which now charges the storage battery as long as the car is running on high gear.

Reverse is usually obtained by means of gears, which in some cases have been arranged to give an extra gear reduction between the armature shaft and driving wheels. Owing to the general design of the Entz transmission, there are just as many speed changes in reverse as in the forward motion.

UNIVERSAL JOINTS

PURPOSE AND CLASSIFICATION

43. In automotive work there are several cases where one rotating shaft must be coupled to another without the use of a rigid coupling, because the peculiarities of installation either prevent such construction on account of the excessive cost, or the conditions of service would cause rapid destruction of the connected parts if a rigid coupling were fitted. In all such cases a flexible coupling usually known as a *universal joint* is used. There are many forms of this joint in actual use in automotive work.

In any automotive vehicle fitted with a shaft-driven rear axle, one or more universal joints must be provided between the engine and the rear axle, in order to make up for lack of alinement between the engine and the axle, due to construction, and also for disturbance of alinement which is due to play of the springs.

In addition to providing for lack of alinement, it is necessary on a propeller-shaft drive to make provision for any variation in the distance between the change-speed gears and the rear axle, or between the clutch and the change-speed gears, the variation in each case being occasioned by the play of the rear springs. In practice, this is allowed for either by constructing the universal joint so that it permits a certain *slip* within itself or by providing the joint with a sliding connection, or *slip sleeve*.

While it is possible in some cases to connect ignition apparatus, electric generators, etc. rigidly to some convenient driving shaft of an engine, in most cases it is necessary to make the driving connection through a universal joint, to take care of original disalinement and also that due to conditions of service.

44. The universal joints actually used in automotive practice can be divided into two general classes: the *all-metal joints* and the *combination joints*. As implied by the name, every integral part of an all-metal joint is of metal, in almost every case of steel. In combination joints, the parts that give flexibility to permit the joining of shafts out of alinement are made in the form of leather or fabric rings, suitably fastened to metallic mountings, which in turn are fastened to the shaft. The combination universal joints employed in automotive practice permit a considerable variation in the length of shafts, and therefore do not in general require the introduction of a slip sleeve on one of them where two are used.

ALL-METAL UNIVERSAL JOINTS

45. While there are many possible types of universal joints made entirely of metal, probably the most widely used form is that known as the *cross type*. A number of variations of this type are met with in practice.

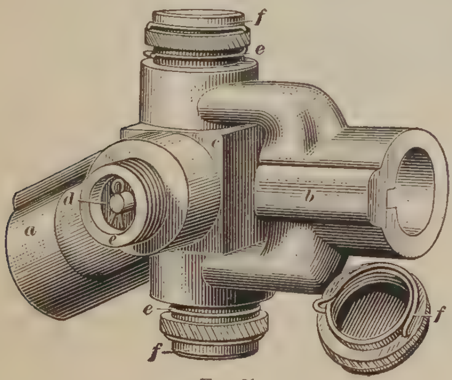


FIG. 21

A cross-type joint made by the Blood Brothers Machine Company, which illustrates the principle of the type very clearly, is shown in perspective in Fig. 21. The joint consists of two forks *a* and *b*, and a cross formed of two members or pins, one passing through a hole crosswise in the enlarged portion of the other, and both passing through a *center*

block c. One of the pins is shown at *d*. The pins turn in bushings *e*, which are of hardened steel, one end being forced into the holes in the forks while the other, to form a longer bearing surface, projects outwardly and is threaded for the grease caps *f*. The center block *c* is a steel cube that fits between the forks and serves to center them and keep them in adjustment. The forks *a* and *b* are intended to be keyed or brazed to the ends of the shafts that they connect, or one fork

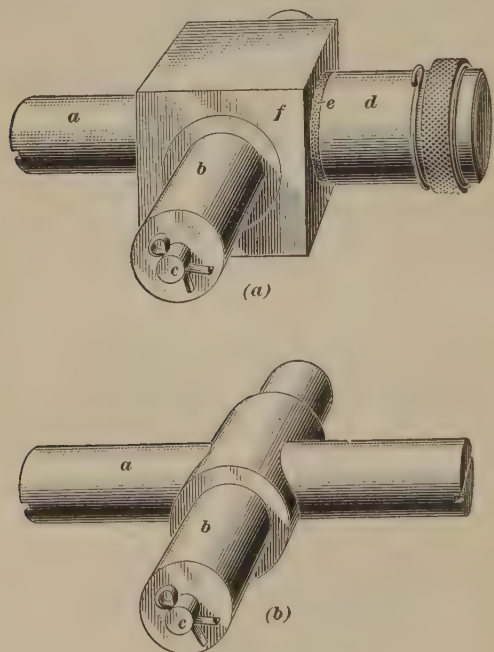


FIG. 22

may be provided with a sliding joint that allows endwise motion of the propeller shaft. The fork *a* is free to turn on the cross-pin *d*, and the fork *b* on the pin at right angles to *d*, thus forming a flexible coupling that may be used to connect two shafts that make an angle with each other.

46. The method of assembling the pins and center block in the universal joint just described is shown in Fig. 22. The pin *a* passes through a hole in the pin *b*, which is enlarged in

the middle as shown in view (*b*). This prevents the enlarged pin from moving endwise. The smaller pin *a* is locked by a third pin *c*, which passes longitudinally through the center of *b* and crosswise through *a*. A bushing with its grease cap is shown in place at *d*, view (*a*). A felt washer *e* is placed between the bushing *d* and the center block *f* and prevents the oil or grease from coming out and the dust from getting in.

The joint can be disassembled by taking off the grease caps and then withdrawing the pins *c* and *a*. In order to take out the enlarged pin, one of the steel bushings must be removed.

It will be understood that the details of construction of the cross-type universal joint which is here shown are peculiar to this particular make; the constructional details naturally vary in accordance with the ideas of different designers.

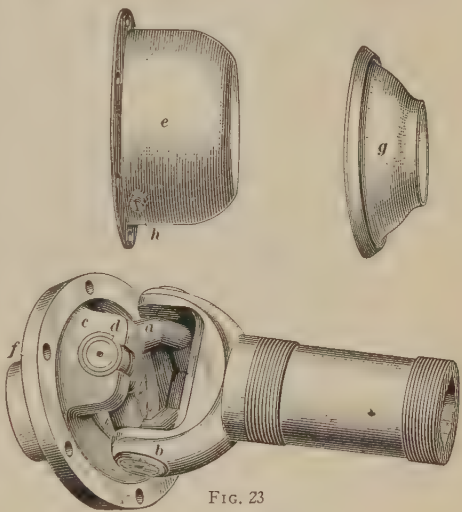


FIG. 23

47. A very widely used variation of the cross type of universal joint is known as the *ring type*, and is commonly used for propeller shafts; a very good example of this is the *Spicer joint*, shown partly disassembled in Fig. 23. The four bearing pins are carried on a *journal piece*, or *ring*, *a*, that joins the forks *b* and *c*. Each journal turns in a hardened-steel bushing *d*. When assembled, the casing *e* is bolted to the flange *f* and the casing *g* fits over the end of the casing *e*. The casing *g* is held in place by means of a clamp that is screwed on the end of the fork *b*. The joint is lubricated through a hole that is normally closed by a screw *h*. A sliding connection may be attached to the yoke *b*, in order to provide for any endwise motion.

48. A universal joint of the *roller type* is shown in Fig. 24; this form of joint is often found between the clutch and transmission where the transmission is a separate unit. A cross-piece *a* on the end of the propeller shaft carries two rollers *b*, which roll in steel yokes *c* in the other half of the joint. The cross and rollers are shown withdrawn from the yoke. The joint is normally protected from dust by a cover, which also acts as a grease retainer. The yoke is made long enough to provide for any necessary endwise slippage.

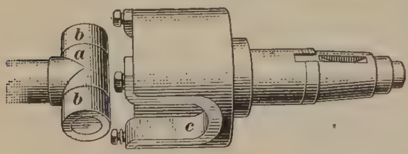


FIG. 24

49. A type of universal joint, known as the *block-and-trunnion type*, is sometimes employed between the clutch and transmission. One member of this joint consists of a slotted jaw *a*, Fig. 25, that contains a square hole *b* in which the squared end of the shaft fits. The second member is a **T** head attached to the end of the other shaft. This head consists of the rounded centerpiece *c*, carrying two arms upon which the bronze or steel blocks *d* are free to turn. When assembled, the blocks are inserted in the jaws of the member *a*, where they are free to slide and permit the desired universal motion. This joint also acts as a slip joint, taking care of any variation of distance occasioned by the jouncing of the automobile on rough roads. The joint is enclosed in a pressed-steel casing *e* that is fastened to the member *a* and contains plugs *f* through which grease can be injected for lubrication. A helical spring is usually placed between the face of the cen-

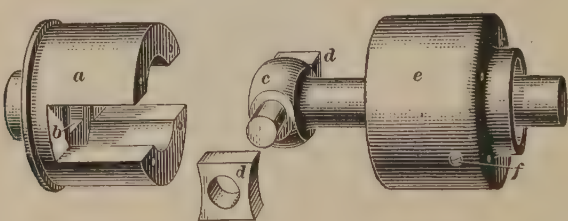


FIG. 25

terpiece *c* and the member *a*, in order to give a cushioning effect. Generally, the head *c* is attached to the end of the propeller shaft and the member *a* to the transmission shaft or differential pinion shaft. A leather boot is usually fitted over the end of the joint to serve as a protection from dust and to help retain the lubricant.

50. The different forms of metallic universal joints so far shown are capable of transmitting great power when made of sufficient size, and are used in automotive work chiefly for propeller- and clutch-shaft drives. For light work, such as driving magnetos, electric generators or motor generators, or battery ignition apparatus, universal joints of the types shown are not only bulky but unnecessarily costly, and other types have been, therefore, developed and have come into use. Probably the best known and most widely used form of an all-metallic universal joint for light work of the kind previously mentioned is the *Oldham coupling,* the principle of which is shown in Fig. 26. It consists of three members, shown separated in order to make the construction clear. Both the driving member *a* and the driven member *b* have a groove cut across the face of the flange, and the connecting member *c* has a rectangular projection on each face, the two projections being at right angles to each other. The projections fit loosely into the grooves of the driving and driven members. The Oldham coupling can be employed only where difference of alinement is very small.

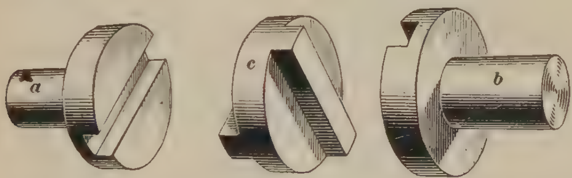


Fig. 26

As a general rule, the three members of the Oldham coupling, for automotive work, are made of wrought steel; sometimes the working faces or even the whole of the three members are hardened to promote long wear.

51. A drawback of the Oldham coupling made entirely of metal is that it produces a disagreeable noise when slightly loose, but this noise can be practically eliminated if the central member is made of some material which does not wear unduly in service, and which gives forth less sound than metal.

52. The Eisemann adjustable Oldham coupling, used to facilitate the timing of ignition apparatus in reference to the engine, in addition to providing for any lack of alinement of shafts, is of the noiseless type mentioned in Art. **51.** It is shown assembled in Fig. 27 (*a*) and its component parts in (*b*). This coupling consists of the steel flange *a*, which is usually fastened to the magneto shaft, the splined steel driving hub *b*, which has a large number of splines on its outside, the two halves *c*, *d* of the steel driving clamp, which are splined inside to fit the splines of the driving hub *b*, and the floating coupling disk *e* made from fabric impregnated with a non-sonorous material called bakelite. After loosening the two screws *f* holding the two halves of the driving clamp together, this clamp can be turned, in steps of 6 degrees each, that is, of one-sixtieth of a revolution, in reference to the driv-

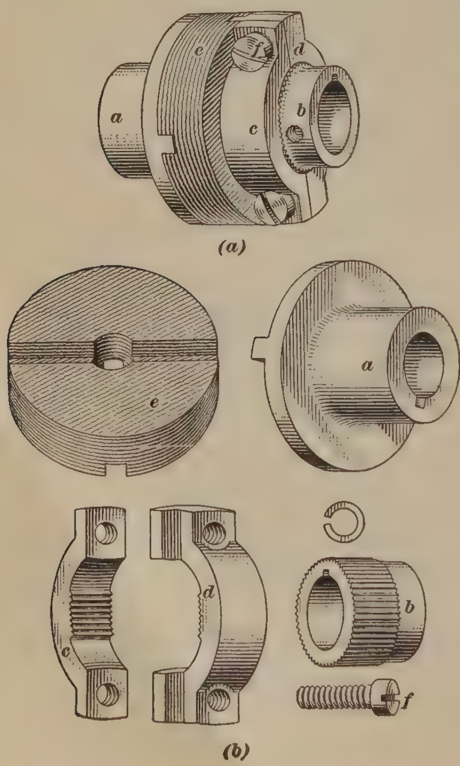


Fig. 27

ing hub *b*, thereby also turning the driving flange *a* in reference to *b*. After adjustment, the two halves of the driving clamp are locked to each other and to the driving hub by means of the screws *f*.

53. The Bosch magneto coupling, shown in Fig. 28, makes use of a laminated steel spring to secure the desired flexibility. The driving member of this coupling consists of a body *a*, view (*a*), that carries a flat laminated steel spring *b* made up

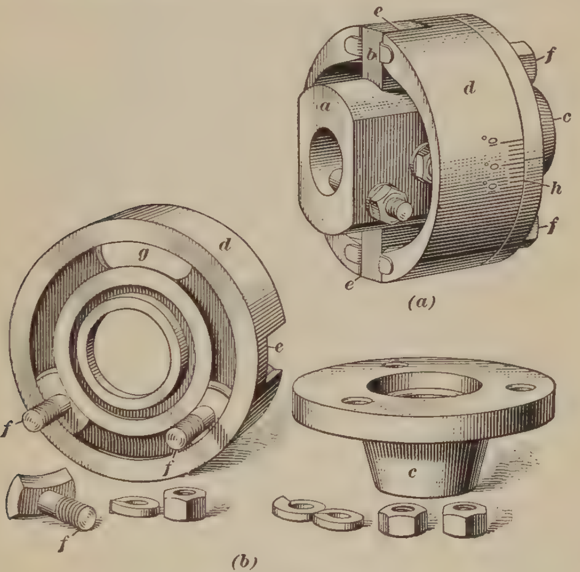


Fig. 28

of a large number of fine spring-steel plates, or leaves. The driven member, which is presented in detail in view (*b*), is a cone-shaped hub *c* that is bolted to a ring *d* having two fiber-lined slots *e* diametrically opposite each other. When assembled, as in view (*a*), the part *c* is attached to the armature shaft of the magneto and the flange *a* is secured to the driving shaft, the ends of the spring carried by *a* being engaged in the slots *e* in the driven member. The drive is through the laminated spring, which gives it the required flexibility. Adjustment for timing the magneto is had by means of three taper-

headed bolts *f* that are held in place in the part *d* by means of a circular groove, into which the heads fit. The ring *d* can be turned relative to the part *c*, and hence to the magneto armature, by loosening the nuts on the three bolts. The bolts may be removed through a slot *g* in the ring *d*.

A distinctive feature of the Bosch coupling is the graduated scale shown at *h*, by means of which the setting of the magneto armature may be accurately regulated.

COMBINATION UNIVERSAL JOINTS

54. While combination universal joints, on account of their silent action when properly built and installed, have been in use for a long time for very light work, such as the driving of electric ignition apparatus and electric generators, they were considered unsuitable for the transmission of a comparatively great torque. In the last few years, combination universal joints have been developed in which, as a general rule, a woven asbestos fabric is used for the flexible part. These have proved very successful for propeller-shaft use, where the torque to be transmitted is quite large.

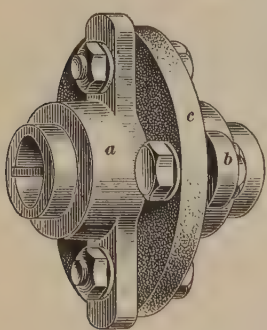


Fig. 29

55. A form of combination universal joint suitable for light work is shown in Fig. 29. This form is widely used for driving ignition apparatus and automobile generators. It consists of two metal flanges, or spiders, *a*, *b*, with suitable bosses bored out and key-seated to fit the shafts to be connected, and a soft leather disk *c*, about ¼ inch thick, bolted to the two two-armed spiders, which, as shown, are approximately at right angles to each other. The flexibility of the leather disk permits a substantial disalinement of the shafts united by the joint, the only condition for satisfactory working of the joint being that the two shafts intersect in the center of the leather disk.

56. The Thermoid-Hardy universal joint, one form of which is shown in Fig. 30, has been developed to transmit successfully a large quantity of power without undue wear. It consists of two either three-armed or four-armed metallic spiders *a, b* placed so that the arms are staggered, that is,

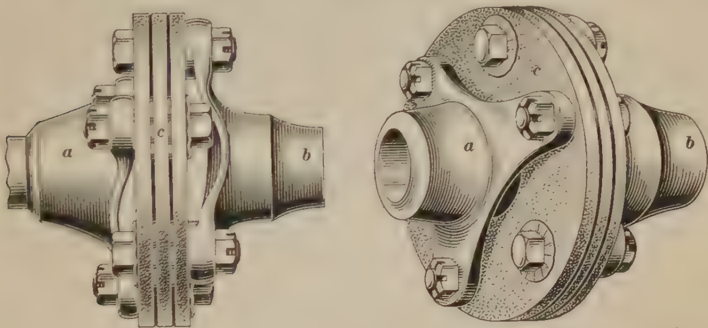


FIG. 30

the arms of one spider are midway between those of the other, with several fabric disks *c* between the spiders and bolted to the arms. The disks, being elastic, serve to some extent as cushions and absorb the shocks. They also render the joint noiseless and flexible.

GENERAL PROPERTIES OF UNIVERSAL JOINTS

57. A single universal joint of any type, no matter how it is constructed, has the peculiarity of not transmitting motion through an angle with a uniform speed. For instance, suppose that in Fig. 31 the shaft *a* represents the main-drive shaft from the transmission and the shaft *b*, the shaft driving the rear axle, the two being connected by the propeller shaft *c*, assuming the change-speed gears to be located at the forward end of the propeller shaft. The angle through which the motion is transmitted is made large in order to show clearly the relative positions of the joints.

Considering only the universal joint connecting the driving shaft *a* and the propeller shaft *c*, if the shaft *a* rotates at a uniform speed, the shaft *c* will not rotate uniformly, but its speed will increase and then decrease four times during each revolu-

tion. This alternate increasing and decreasing of the driven shaft is due to the alternate increasing and decreasing of the radii through which the forks of the joint revolve. For instance, in the position shown in Fig. 31, a point *f* is at a certain perpendicular distance from the center line of the driving shaft *a*, but this distance gradually increases as the shaft *c* turns through the next quarter of a revolution. The linear velocity, therefore, of the point *f* also increases, provided that the speed of the driving shaft *a* remains uniform. During the second quarter of a revolution, the speed of the point *f* decreases until the point reaches the position marked *f′*, after which the speed again increases for a quarter of a revolution.

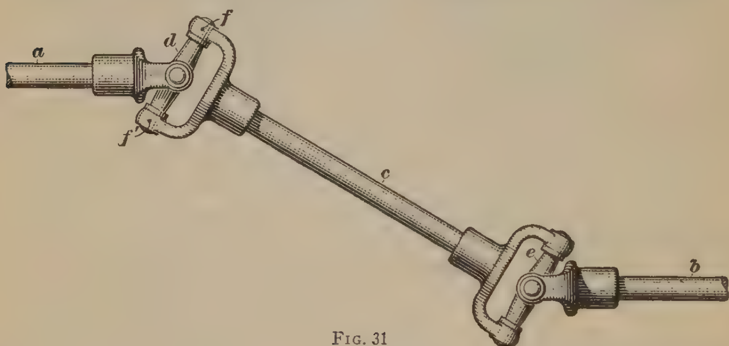


Fig. 31

On the fourth quarter of a revolution, the speed of the point *f* decreases until it reaches the position shown in the illustration. The speed of the shaft *c* varies with that of the point *f*, which is fixed with reference to *c*; hence, the driven shaft *c* will not rotate uniformly if the driving shaft *a* moves at a uniform speed.

58. By the proper use of a universal joint at each end of the propeller shaft, however, the shaft *b* can be made to rotate at the same speed as the shaft *a* during all parts of a revolution. In other words, the connection between the shafts *b* and *c* can be made to counteract the variable speed of the shaft *c* as produced by the connection between the shafts *c* and *a*. In order to do this, it is only necessary that the forks on the shaft *c* shall lie in the same plane. This may be otherwise

expressed by saying that the shaft *c* must have such a form that if it is removed with the attached forks from the crosses *d* and *e* and placed on the floor, it will lie flat. It is also required that the shafts *a* and *b* make equal angles with the intermediate, or propeller, shaft *c*. This, of course, is the case when the shafts *a* and *b* are parallel, as shown in the illustration.

This discussion is given for the purpose of pointing out the necessity of correct assembly of shafts united by two universal joints, in order that the irregularities of motion produced by the one joint may be neutralized by the other joint; if the joints are assembled wrongly, the irregularity of motion produced by the one joint may be even doubled by that of the other joint.

CONTROL MECHANISMS

STEERING MECHANISMS

ARRANGEMENT OF STEERING CONNECTIONS

59. When a car is traveling straight ahead, the wheels stand in the position shown by the full lines in Fig. 32, which is a diagrammatic outline of a top view of the frame, axles, and wheels of an automobile. The axles of the wheels are parallel to each other when looked at from above, as in this view. If the car is to turn a curve whose center is at *a*, the front wheels *b* and *c* must be swiveled about the more or less vertical pivots *d* and *e* of their respective knuckle joints. When turning toward the left, as indicated in the figure, the left-hand front wheel *b* must swivel through a greater angle than the right-hand front wheel, which is at the outer side of the curve along which the car is traveling. The path that the left-hand wheel follows is indicated by the arc *f g* whose center is at *a*, and the path of the right-hand wheel is along the arc *h i*, whose center is also at *a*. In order that the front wheels may have a true rolling motion on the ground, it is necessary for them to swivel to such an extent that their axes, if extended, will intersect on an

extension of the rear axle as shown. The lines *a d* and *a e* represent extensions of the axes of the front wheels. The angle through which the left-hand wheel must be swiveled is shown at *j*, and that through which the right-hand wheel must be swiveled, at *k*. It can be readily seen that the arc *j* for the left-hand, or inside, wheel is larger than the arc *k* for the outside wheel *c*.

60. One of the two methods of connecting wheels together to fulfil the conditions just mentioned is shown in Fig. 33. The

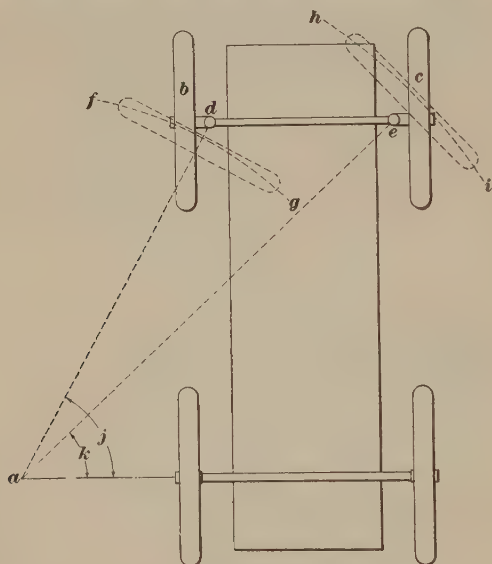


FIG. 32

full lines indicate the position of the steering mechanism for the car to go straight ahead. The arms *a* and *b* of the steering knuckles are connected by the distance rod, or tie-rod, *c*. These arms *a* and *b* stand in such a position when the car is going straight ahead, that if a line is drawn through the center of the swivel pin *d* of one of the knuckle joints and also through the center of the pin connecting that arm to the distance rod, and another line is similarly drawn through the swivel pin *e* and the pin connecting the corresponding arm to the distance rod, these two lines will intersect on or near the

center line of the axis common to the rear wheels, as indicated at *f*. The length of the distance-rod arms *a* and *b* on the steering knuckles is made such that when the wheels are swung around to turn a curve, the wheels will take positions in which their axes, if extended, would intersect on or near an extension of the center line of the rear axle. The intersection for this position is shown at *g*.

If the steering mechanism were mathematically correct in its operation, then, for any position of the swiveled road

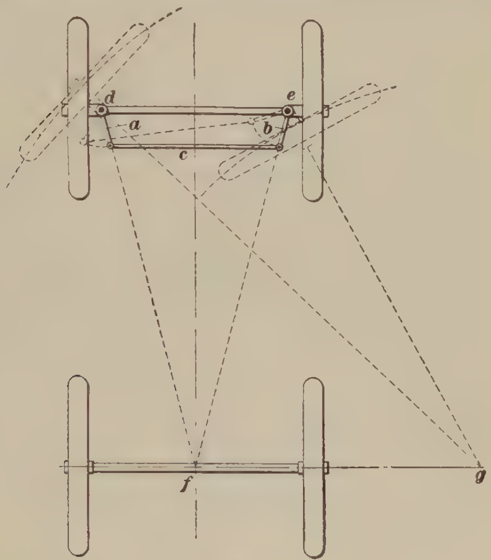


Fig. 33

wheels, the intersection of the extended axes of the front wheels would lie exactly on the extension of the center line of the rear axle. The mechanism shown, however, does not exactly give this result, but one that is near enough for all practical purposes.

61. The second method of connecting the front wheels is by placing the distance rod in front of the front axle with the arms of the knuckles extending forwards to engage with it. In this case, the distance between the ends of the steering-knuckle arms is greater than the distance between the steering-knuckle

pins. The same condition exists as to the lines through the steering-knuckle pivots and connections of the distance rod intersecting at or near the center of the rear axle.

While the second method of connecting the front wheels gives a closer approach to a theoretically correct layout of the steering mechanism than the first method explained, yet the practical objection of exposing the tie-rod to injury to a greater degree than exists in the first method, has caused its use to be confined to but few cars. Practically all makes of modern cars use the first method, which is explained in Art. **60.**

STEERING GEARS

62. Classification.—*Steering gears* may be broadly divided into *tiller steering gears* and *wheel steering gears*. In a **tiller steering gear,** steering is effected by moving by hand a long lever, which in turn is connected by suitable means to one of the steering knuckles; this form of steering gear is now used only on some light electric vehicles. In a **wheel steering gear,** as implied by the name, steering is effected by turning a wheel, ranging in modern cars between 16 and 20 inches in diameter.

Steering gears may also be classified as *reversible* and *irreversible steering gears*. When an obstruction struck by one of the road wheels will cause the hand steering wheel to rotate and thus deflect the car from its direction of travel, unless the steering wheel is very firmly gripped by the hands of the driver, the steering gear is called a **reversible steering gear.** It is evident that the reason for the name is that it is possible to rotate the hand wheel by force applied to one or both of the road wheels. A steering gear that cannot readily be reversed in this manner is called an **irreversible steering gear.** While none of the steering gears in actual use fully possess this property of irreversibility when in good working order, they are usually referred to as being irreversible when but little effort at the hand wheel is required to keep the car from being deflected from its path when the road wheels strike an obstruction.

63. Various methods are employed for connecting the lower end of the inclined shaft that carries the steering wheel to the reach rod, in order to transmit the required motion to the steering knuckles. In every case, a turn of the wheel rotates a short arm that in turn rotates the steering knuckles through the reach rod. The steering mechanism at the bottom of the inclined shaft usually consists of a worm and complete worm-wheel or a worm and sector, although some form of screw-and-nut or pinion-and-gear connection is also sometimes used. In just one car, which is the model T Ford, the lower end of the shaft is connected directly to the reach rod by a short crank-arm, while a planetary gear-set is provided at the top for transmitting the movement from the wheel to the shaft.

64. Worm-and-Worm-Wheel Steering Gear.—The most popular type of steering gear is that employing a worm and worm-wheel. One model of the Gemmer steering gear, which is an example of this type, is shown in Fig. 34. Part of the steering wheel and column is cut away, exposing to view the interior arrangement. Within the stationary housing *a* is the steering shaft, or mast, *b*, carrying at its upper end the steering wheel *c* and at its lower end the worm *d*. The worm is supported at its top and bottom by two ball thrust bearings *e*, the mast being also provided near the top with a spring bushing *f*, in order to prevent rattling. The thrust bearings can be adjusted by means of the adjusting nut *g* that screws into the housing *h*. A second stationary tube *i* is located inside of the mast *b*; its function is to carry the quadrant *j* at the top of the mast, or shaft. This tube contains two other tubes, *k* and *l*, by means of which motion is transmitted from the throttle and spark levers, *m* and *n*, to the arms *o* and *p*, respectively. The electric-horn push button *q* is located in the center of the steering wheel and is wired to the horn through the inner tube *l* by means of the wire *r*; this is present-day standard practice, an electric horn of some kind being universally employed as a signaling device on all passenger cars and on many commercial cars.

When the steering wheel is rotated, the mast *b* transmits the motion to the worm *d* and this, being in mesh with the worm-

wheel *s*, causes that wheel to turn. The shaft *t*, which carries the short arm *u*, is integral with the worm-wheel *s* and, hence, rotates with any motion of the steering wheel and in turn causes the steering knuckles to be rotated by the reach rod, which, however, is not shown in the illustration. The steering mechanism is so constructed that a turn of the steering wheel

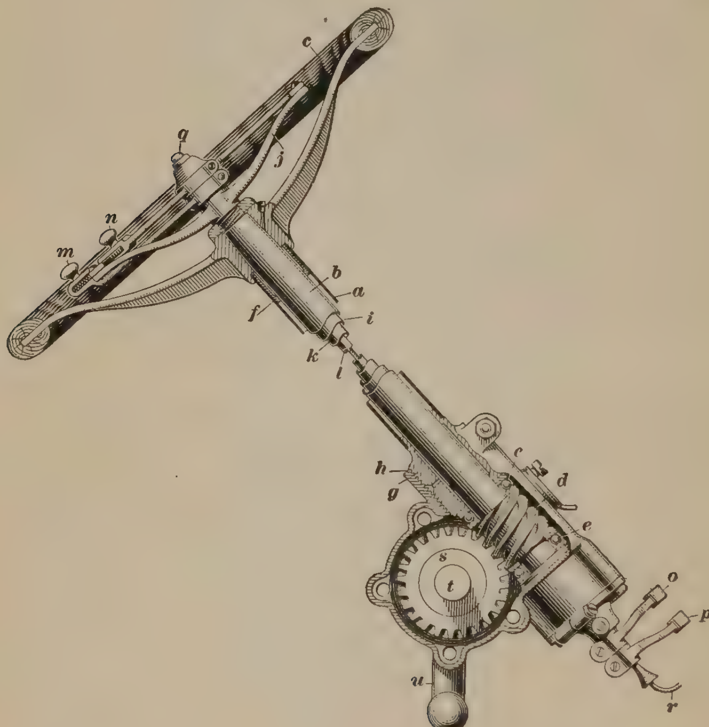


FIG. 34

toward the right swings the front wheels to the right and steers the car in that direction. A turn of the steering wheel to the left steers the car to the left.

Adjustment of the steering gear for wear is made by changing the position of the crank-arm *u* in relation to the worm-wheel *s*; when the worm-wheel has worn appreciably in one place, an unworn portion can be brought into mesh with the

worm by turning the arm through 90° on the squared end of the worm-wheel shaft. This steering gear is of the irreversible type.

65. Worm-and-Sector Steering Gear.—In the worm-and-sector steering gear, a worm on the lower end of the steering shaft, or mast, meshes with a sector of a worm-wheel instead of with a complete wheel. An example of this type is shown in Fig. 35 with the two parts of the housing separated. The worm *a* is carried on the lower end of the steering shaft *b*, as in the worm-and-wheel type, but in this case it meshes with a sector *c*. The worm is fitted with two thrust bearings, one of which is shown at *d*. The two bearings are made adjustable in the direction of the steering shaft *b*.

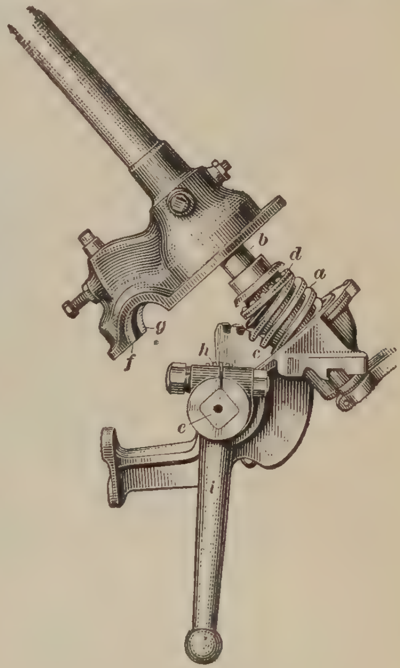


FIG. 35

The sector shaft *e* is carried on two bearings, the caps of which are shown at *f* and *g*, and is made adjustable by means of two eccentric bearing bushings that can be turned to any position, thus moving the sector closer to or farther from the worm, as desired. The eccentric bushings can be locked in any position by means of teeth *h* cut in their periphery and a locking pin that screws into the casing and meshes with the teeth. The eccentric bushing is a common form of adjustment in this type of steering mechanism. The arm *i* is the crank-arm which operates the reach rod; it is clamped to the squared end of the shaft *e*, as shown. This is also a form of irreversible steering gear.

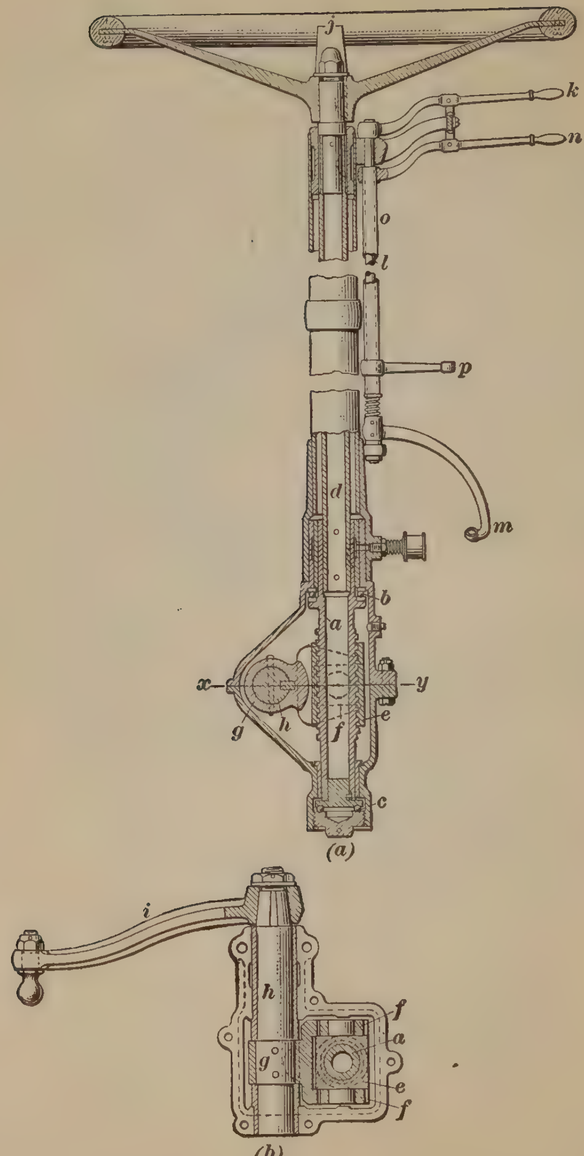


Fig. 36

66. A feature of one design of steering gear is that the steering wheel is hinged in front so that it can be dropped downwards, thus facilitating entrance and exit on the driver's side of the car. However, practically all other steering gears are provided with a steering wheel that is attached permanently to the steering shaft and cannot be dropped. There are a number of adjustable steering wheels on the market, and one of these can be applied to practically any car in place of the stationary wheel supplied with the car.

67. Screw-and-Nut Type Steering Gear.—An irreversible steering gear of the screw-and-nut type is shown in Fig. 36. View (*a*) is a vertical section of the steering column and wheel and view (*b*) is a sectional view through the plane *x y*. In this device, a multiple-threaded screw *a*, confined endwise by ball thrust bearings *b* and *c*, is attached to the lower end of the steering shaft *d* and actuates a nut *e*. The nut is provided with projections, or trunnions, carrying blocks *f* that rest in slots of a forked lever *g*. The lever *g* is keyed and pinned to a spindle *h* that carries the reach-rod crank-arm *i*. Rotation of the steering wheel *j* causes the nut *e* to travel up or down, thus swinging the lever *g* and actuating the crank-arm and reach rod through the spindle *h*. The steering gear shown is an example of one with the shafts for operating the throttle and spark advance located outside of the steering column. The lever *k* operates the throttle by means of the shaft *l* and arm *m*, and the lever *n* is connected to the spark-advance mechanism through the tube *o* and the arm *p*. These levers and connections are carried on the outside of the steering column by suitable brackets.

68. Fig. 37 shows the mechanism of the Jacox screw-and-nut type steering gear, which makes use of a right-and-left threaded screw and two half nuts instead of a single nut. The screw *a*, which is attached to the lower end of the shaft that carries the steering wheel, has two threads cut over each other—one right-handed and one left-handed. The half nuts *b* and *c* surround the screw, one meshing with the right-hand thread and the other with the left-hand thread so that

one slides up and the other slides down within the gear housing *d* when the screw is rotated. To the lower end of each of these half nuts is pinned a hardened-steel block *e* that bears on a roller *f* at each end of a rocker *g*. The rocker is mounted on a horizontal shaft *h* that also carries the reach-rod crank-arm.

When the steering wheel is rotated so as to cause the half nut *b* to travel upwards and the half nut *c* downwards, the bearing block *e* under *c* presses downwards against its roller and turns the rocker *g*. Motion is thereby imparted to the

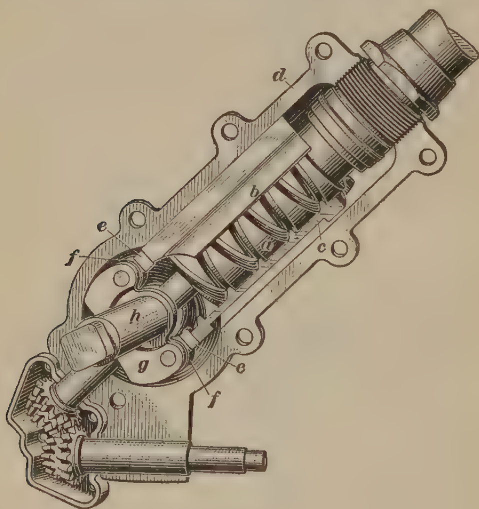


FIG. 37

shaft *h* and to the reach rod, by means of which the front wheels are swung in the direction desired.

The bevel pinions at the lower end of the steering mechanism connect the shafts belonging to the mechanism for operating the throttle and spark advance.

69. Bevel-Pinion-and-Sector Steering Gear.—The Reo steering gear, shown in Fig. 38, is an example of the bevel-pinion-and-sector type and belongs to the reversible class. Because of the nature of its construction, this mechanism transmits a shock from the front road wheels to the steering

wheel much more readily than the gears previously described. On cars equipped with reversible steering gears it is good practice to have the steering-knuckle pins set so that very little motion can be transmitted from the road wheels to the steering mechanism. This may be accomplished by inclining either the knuckle pivot pin or the wheel spindle, or both, so as to bring the pivot pin in line, or nearly in line, with the point where the wheel touches the ground.

70. Referring to Fig. 38, a bevel pinion *a* is keyed to the steering shaft *b* and meshes with a sector *c* of a bevel gear. The sector is mounted on a short shaft *d* that also carries the

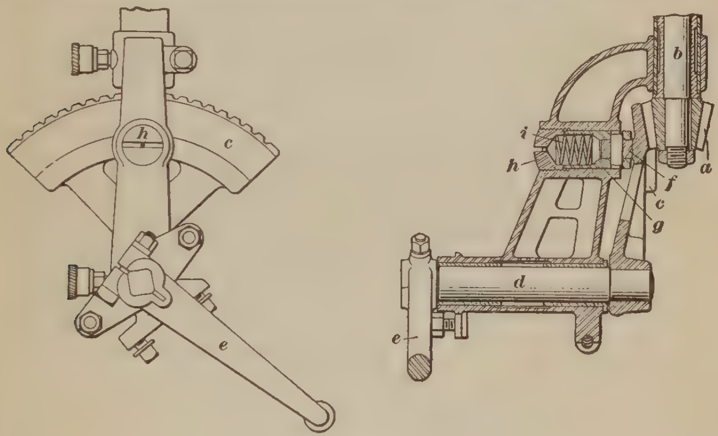


FIG. 38

reach-rod arm *e*. A movement of the steering wheel rotates the pinion and this in turn rotates the sector and transmits the motion to the crank-arm, which is connected to the steering-knuckle pins in the usual manner. The thrust of the bevel-gear sector is taken by a roller *f* that is carried by a plunger *g*. Adjustment of the sector is had by means of a screw *h* that is used for adjusting the position of the plunger *g*. A spring *i* is located within the screw and plunger, which are made hollow. This spring always keeps the roller in contact with the sector.

71. Planetary Type of Steering Gear.—In the planetary type of steering gear, which is used only on the model T

Ford car, the gearing is located at the top of the steering column. The inclined steering shaft is connected directly to the reach rod by a crank-arm that is keyed to its lower end. However, the steering wheel is not fitted to the upper end of this shaft as in the gears previously described, but is connected to it through a small planetary gear-set. The arrangement of the gears of this set is shown diagrammatically in Fig. 39. The internal gear *a* is stationary, being brazed to the outside tube of the steering column. Meshing with this gear are the three planetary gears *b* that are mounted on pins carried by the head of the steering shaft. The small spur gear *c* is integral with a short shaft that has a bearing in the steering shaft and that carries the steering wheel. This gear meshes with the three planetary gears *b*.

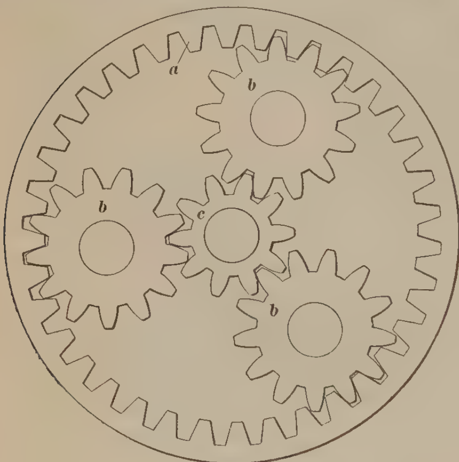


Fig. 39

When the center gear *c* is turned by the steering wheel, motion is imparted to the planetary gears *b* and they are rolled around the stationary gear *a* in the same direction in which the center gear is turned. The planetary gears *b* are thus carried bodily around and as their pins, or studs, are attached to the upper end of the steering shaft, they turn that shaft with them. A movement, therefore, of the steering wheel, turns the inclined shaft and swings the reach-rod arm, imparting motion to the steering knuckles in the usual manner.

The planetary steering gear is of the reversible type, as motion can be imparted to the steering wheel by moving the front wheels.

The only adjustment in this type of steering gear is to remove small pinions *b* and internal gear *a*, and replace by new ones.

BRAKE MECHANISM

CONTRACTING AND EXPANDING BRAKES

72. The brakes used in automobile practice consist of a cylindrical member, or *brake drum,* attached to some rotating part, and a contracting or expanding member, or *brake band,* supported by some fixed part of the car. The brake band is applied by levers operated from a pedal or hand-brake lever. If the band is of the contracting type and is applied to the outside of the drum, the brakes are called **contracting brakes;** if it is an expanding band and is applied to the inside of the drum, they are called **expanding brakes.** It is the usual practice to fit two entirely separate sets of brakes to automobiles. The one brake system is used in ordinary service, and is therefore called the **service brake.** The second brake system is intended for emergency use, and the term **emergency brake** was formerly applied to it. In modern practice, as this brake is always applied by a hand lever, it is called the **hand brake.**

It is becoming the common practice to place the service brake on some rotating part of the speed-changing mechanism, or on a drum placed directly on the propeller shaft, and to apply the emergency brakes to a drum fastened to each rear wheel, although in some cases the service brake acts on the wheel hub, and the emergency brake on the transmission shaft. The former practice was to apply both brakes to drums bolted to the rear-wheel hubs, making the one contracting and the other expanding; this practice is still quite prevalent. Either the service brake may be of the contracting type and the emergency brake of the expanding type or vice versa. There is no fixed rule governing the type of either set of brakes. In a few cars, however, both sets of brakes are of the expanding type and are located side by side within a single brake drum.

73. Formerly the expanding or contracting member of brakes was made in two halves hinged together, the halves being either steel castings, malleable-iron castings, phosphor-bronze castings, or occasionally plain cast iron. Friction was obtained either by a metal-to-metal contact with the brake drum, or by metal and cork inserts, or by some friction lining like camel's-hair belting, or even ordinary leather belting.

74. In modern practice the use of a metal-to-metal contact is virtually confined to brakes furnished as standard equipment on the rear wheels of the model T Ford car, where a one-piece cast-iron expanding brake shoe is used in each brake drum. In standard modern practice brake bands of both the contracting and expanding type are made of spring steel from $\frac{1}{16}$ inch to $\frac{1}{8}$ inch thick and from $1\frac{1}{2}$ to 3 inches wide; of course in exceptional cases the dimensions may be greater or less. The fittings necessary for supporting and applying the brake bands are either malleable-iron or steel castings, or drop forgings, and are secured by rivets.

The friction surface of brake bands, when metal-to-metal contact is not employed, is formed in present-day practice of non-burnable pliable material. The material used is a woven asbestos fabric, closely woven over copper or brass gauze, and compressed under high pressure. This material comes in long rolls, in thickness from $\frac{1}{8}$ inch to about $\frac{5}{16}$ inch, and in widths from 1 inch and above; it is sold by automobile supply stores under various trade names, like raybestos, multibestos, thermoid, etc., coined by its manufacturers. The friction fabric is attached to the brake bands by copper rivets having heads sunk well below the contact surface of the fabric.

75. The most common form of hub brake consists of a contracting brake, operated by means of a bell-crank, and an expanding brake, operated by means of a cam. An example of this form is found in some designs of the Timken-Detroit rear axles, and is shown in Fig. 40. In order to show the details of the operating mechanism, the brake drum is omitted from the illustration.

The contracting band *a* is lined with wire-woven asbestos fabric. It is attached at one end to the short arm of a bell-crank *b*, and at the other end it connects through a short link *c* to the fulcrum of the bell-crank. The long arm of the bell-crank may be connected by rods and levers to either a pedal or a hand lever, and the brake is then applied by exerting a pull in the proper direction on this arm. When the brake pedal or lever is released, the elasticity of the steel band *a* draws it away from the drum. In addition to this, a releasing spring *d* is pro-

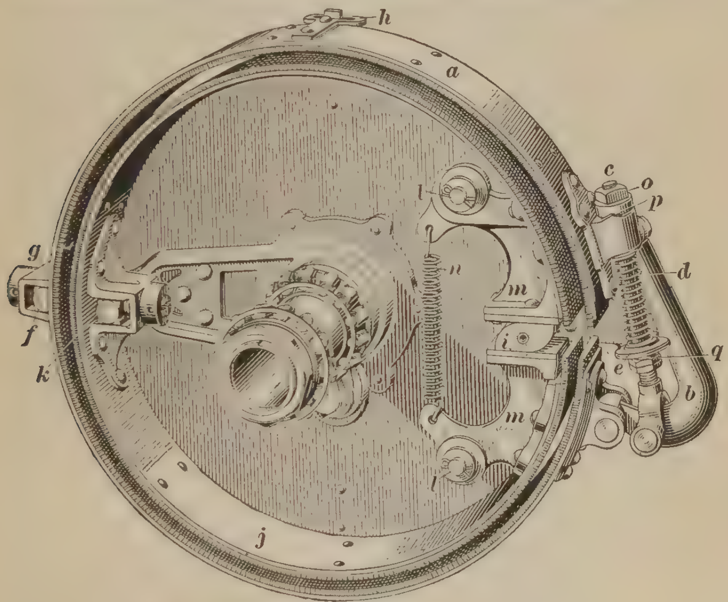


FIG. 40

vided. This spring seats on a stop *e* that is stationary, so that when the brake is applied, the spring is compressed. When the brake is released, the spring expands and helps to expand the band *a*. On the side of the brake opposite the operating mechanism there is a support *f* that helps to carry the band by means of a bracket *g*. Between the support and the outer part of the bracket there are two springs that tend to keep the brakes from rubbing on the drums when not in use. The action of these springs can be limited by means of an adjusting screw.

Two supports *h*, one located on top and the other on the bottom of the band *a*, preserve the brakes in their correct alinement.

76. In the cam-operated expanding brake shown in Fig. 40, the double cam *i* acts on bearing surfaces carried on the ends of the asbestos-lined band *j*. The band *j* is supported at *k* in the same manner that the band *a* is supported at *f*. Two stops *l*, which are pins secured to the axle housing and passing through slotted holes in the brackets *m*, hold the expanding band in sidewise alinement. The spring *n* is the releasing spring and holds the ends of the band in contact with the double cam *i*. The supports *f* and *k* are carried on an extension of the axle housing.

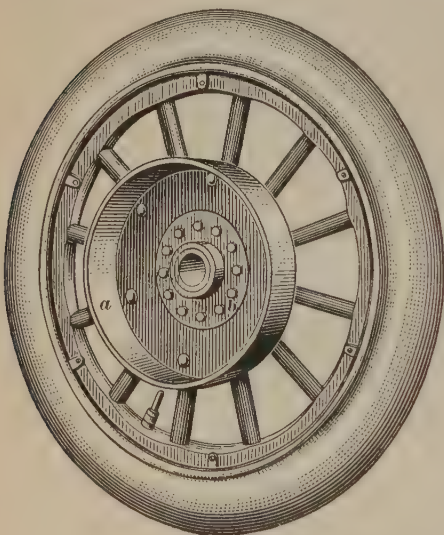


FIG. 41

77. Adjustment of the contracting brake is made by means of the nut *o*, Fig. 40, on the end of the link *c*. This nut is provided with a notch *p* that fits over a corresponding projection on the supporting bracket; hence, the least adjustment that can be made is one-half of a turn of the nut. The adjusting nuts at *q* are used for centering the band on the brake drum, the nut *o* taking care of the actual adjustment.

The expanding brake is adjusted by lengthening or shortening the brake rod by means of a suitable turnbuckle.

78. The standard application of a brake drum to a rear wheel is shown in Fig. 41. The brake drum *a* is usually pressed from sheet steel, and is bolted to the wheel hub *b* or to the spokes of the wheel, or to both, so as to run true. When

applied to a wire wheel or disk wheel, the drum is fastened only to the wheel hub.

79. When a brake is applied to the propeller shaft or to the transmission, this may serve either as the foot brake (service brake) or as the hand brake (emergency brake), practice in this respect not being settled as yet. An example of a service brake applied to a drum on the main shaft of the transmission, as found in some Mercer cars, is shown in Fig. 42. The brake consists in this case of two shoes *a* and *b* that are lined with asbestos fabric and surround a drum *c* on the shaft *d*. The brake is located close to the transmission casing *e* and the actuating mechanism is supplied by that casing. The shaft *f* carries two screws, one right-handed and the other left-handed, that turn inside of the nuts *g*. When the shaft is rotated in the proper direction, the nuts move toward each other and tighten the shoes by means of the lugs *h* that impinge on the shoes. The releasing spring *i* aids in separating the shoes when the brake is released by the foot pedal. The advantage claimed for this brake is that the same force is always applied to both rear wheels. Also, a rather small force applied to the brake produces a large retarding force at the rear wheels, owing to the gear reduction between the propeller shaft and rear wheels.

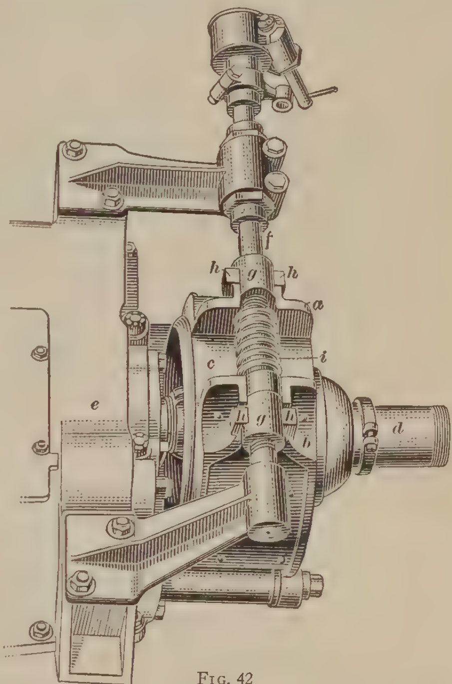


Fig. 42

While some shaft brakes, like that shown in Fig. 42, employ two brake shoes, yet the majority of such brakes have a steel brake band lined with suitable friction material. On some transmission contracting brakes, a bell-crank is used as in some hub brakes.

BRAKE EQUALIZERS

80. Unless some means are provided for keeping the tension equal in the two rods that connect to the shoes of a pair of hub brakes, one of the shoes, when applying the brakes, will bear against its drum harder than the other if the adjustment is not exactly the same for each brake. Such adjustment is not particularly difficult to make for an expert mechanic who is accustomed to this work, yet the increasing difficulty of finding such men has caused car-makers to turn toward the use of devices which in themselves will apply both brakes equally. It will be understood that when one hub brake grips harder than

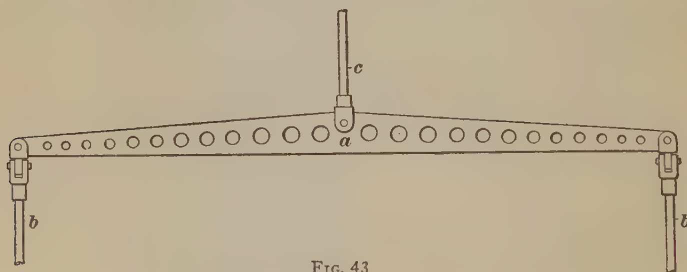


Fig. 43

its mate, there is a tendency to slew the car away from the side on which the brake has the weaker grip.

Various forms of **brake equalizers** are used to obtain equal force of application for a pair of hub brakes. A simple form of equalizer is a bar *a*, Fig. 43, extending across the car, and having at each end a connection to one of the tension rods *b* that run back to the brake shoes; there is also a connection at the middle of the bar to the rod *c* that connects to the brake pedal or hand lever by means of which the driver applies the brakes. The pull on the rods leading from the brake shoes will, of course, be the same with this arrangement.

81. A rather common brake equalizer consists of separate crank-shafts, one for each brake shoe, placed in line with each other across the length of the car. The crank-levers at the outer ends of the shafts are connected to the tension rods that run back to the brakes, and the crank-levers at the adjacent inner ends of the divided shaft are connected to a short equalizer bar in the same manner as just described when the bar extends completely across the car.

An arrangement of this kind is shown in Fig. 44. The middle of the short equalizer bar *a* is joined to the service-brake rod that runs forwards to the operating pedal. The ends of

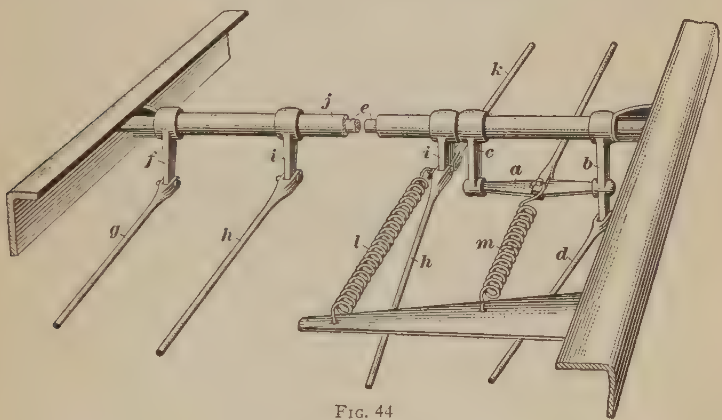


FIG. 44

the bar are joined to two separate cranks *b* and *c*, one of which is also connected to one of the service brakes by a rod *d*. The other crank *c* is carried by the shaft *e* that extends across the car and carries at its outer end a second crank *f*, which in turn is connected to the second service brake by a tension rod *g*. Thus, the pressure on the service brakes is equalized by the bar *a*. The emergency brakes are not provided with an equalizer. These are operated through the rods *h* and the cranks *i*, which are mounted on a tube *j*. The tube is rotated by a hand lever through one of the cranks and the rod *k*. The springs *l* and *m* aid in releasing the brakes.

In other equalizers of this type the rod *d* is joined to a separate crank connected by a shaft to the equalizer crank *b*.

82. While the brake equalizers here shown are not the only ones made, yet they are the most common ones; a knowledge of their principle of action enables a person to trace out readily the operation of any other design of this device. Even with a brake equalizer of the most effective form, the resistance that a pair of hub brakes offers to the rotation of the wheels is not the same, unless the coefficient of friction between the rubbing surfaces of the brake shoe and of the drum is the same in each case. Thus, if one brake is dry and the other oily, they will not grip the wheels so as to resist the rotation of each wheel with equal force, even though the pressure of the shoe against the drum is the same for each brake.

Probably the most serious practical objection to the brake equalizers is that when their joints become dry and rusty, one or the other of the two brakes may fail to release entirely, dragging quite heavily on the drum to which it is applied. Even though the loss in power caused by this dragging may not be serious, yet the dragging may produce highly offensive noises.

Many attempts have been made to use brake equalizers employing wire cables as tension members, but such attempts have not as yet proved entirely successful.

BEARINGS AND LUBRICATION
(PART 1)

BEARINGS

PLAIN BEARINGS

DEFINITIONS

1. The oldest and simplest form of bearing that is widely used in automobile practice, not only in the engine, but also in parts of the running gear, is that known as a **plain bearing.** Such a bearing consists essentially of two parts, namely, a member, called the *journal*, having a surface that fits freely a corresponding hole in another member, called the *box*. One of these two members is stationary and the other is free to revolve or to slide in the direction of its axis.

Plain bearings are of two general types: *non-adjustable* and *adjustable*. There are two classes of non-adjustable bearings, namely, those having a *bushed box*, that is, a box fitted with a removable solid bushing or liner, and those having no bushing. In adjustable bearings, the box is divided into two parts; such division is made for convenience in assembling the bearing and taking it apart, and also for making adjustments to take up wear and to secure a proper fit between the journal and the box. A lining is very often used between the journal and the main body of the box. The object of using the lining is to provide a more suitable material for the journal to rub against than that which is used for the supporting parts or

frame of the machine, or to provide a ready means of replacing a worn part. This lining is made in two parts to suit the two parts of the box; when the lining is made separate from the box and is readily removable, its two parts are spoken of as the *bearing brasses*. This term, however, does not necessarily mean that the lining is made of brass.

Although, in most bearings used in automobile work, the journal rotates in the box, as, for instance, in the crank-shaft and cam-shaft bearings of the engine, there are others in which the moving member slides back and forth in the box, as, for instance, the valve stems and valve lifters of the engine and the sliding gears of the transmission.

NON-ADJUSTABLE PLAIN BEARINGS

2. The class of non-adjustable plain bearings in which no bushings are used is confined in automobile work chiefly to joints on the brake connections, the transmission rods, the tie-rod joining the steering knuckles, and in similar places where there is very little movement and hence little wear.

The form that these bearings usually take in automobile work in the places referred to is known as the *yoke-and-eye rod*,

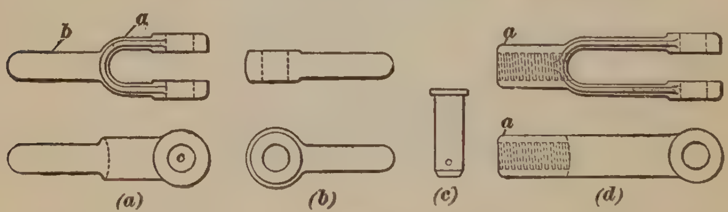


FIG. 1

of which the yoke is made either *adjustable* or *plain*. The proportions of yoke-and-eye-rod bearings have been standardized by the Society of Automobile Engineers, and their recommendation is now largely followed by manufacturers.

3. Fig. 1 (a) shows a **plain yoke end** consisting of a fork a and a circular stem b. A hole c is drilled through each jaw of the fork. The stem b is welded to the rod to which the yoke

end is to be applied, the yoke end being made from drop-forged steel. The eye-rod end is shown in (*b*); it fits between the jaws of the yoke end and has drilled through it a hole of the same size as that in the fork jaws. The yoke end and eye-rod end are connected by passing through them a pin like that shown in (*c*); this pin has an enlarged head at one end and drilled through it at the other end is a hole through which is passed a cotter pin when the yoke-and-eye-rod ends are assembled.

An **adjustable yoke end** is shown in Fig. 1 (*d*). The cylindrical stem *a* of this yoke end is larger than that of the plain

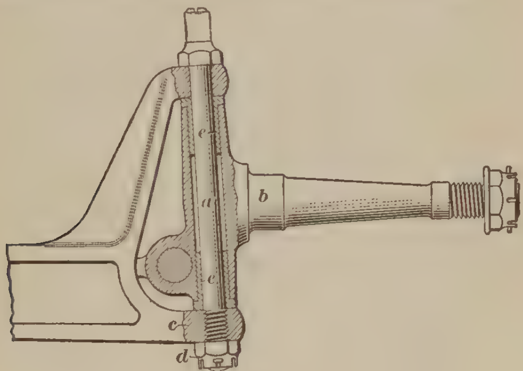


FIG. 2

yoke end, and it has a central hole drilled through it and tapped out. The yoke end is attached to its rod by screwing it on, and the length of the rod may be adjusted to a slight extent by screwing the yoke end to the right or to the left.

In yoke ends and eye-rod ends, the holes may be considered to be the boxes, and the pin to be the journal, of the bearing; motion can occur only in a plane at right angles to the joint pin.

4. A **non-adjustable bushed bearing** is shown in Fig. 2, which illustrates one front-axle end and steering knuckle of the Ford car, model T. The spindle bolt *a* upon which the steering knuckle *b* turns is stationary in the axle end, being screwed into the lower jaw *c* and locked by a locknut *d* and a

cotter pin. The steering knuckle is fitted with two removable bushings *e*, which are pressed into it, and on the inside of these bushings is a close working fit on the spindle bolt. This bolt in this case forms the journal of a bearing and is stationary; the steering knuckle, with its two bushings, forms the box of the bearing and is movable.

The object in bushing a plain non-adjustable bearing is to permit an easy restoration of a proper working fit between the journal and the box by substituting new bushings and perhaps a new journal for the old and worn-out bushings and journal.

5. Bushed plain non-adjustable bearings have been used on rear axles for the driving pinion shaft and also for the driving shafts; they have also been used for the end bearings of crank-shafts, although their use for this purpose is now uncommon. The cam-shafts and pump and magneto shafts of engines very frequently run in bushed boxes.

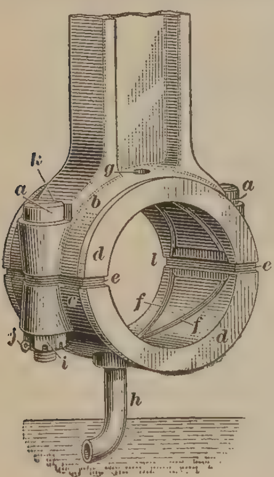


Fig. 3

ADJUSTABLE PLAIN BEARINGS

6. A typical **adjustable plain bearing** is shown in Fig. 3, which illustrates the crankpin end of the connecting-rod used in some Northway motors. The connecting-rod is made of drop-forged steel; its large end is bored out cylindrical, the holes for the bolts *a* are drilled, and the forging is then sawed apart. The box is thus formed by the connecting-rod *b* and the cap *c*, and is lined with removable bearing-metal brasses *d* that have a flange at each end to confine them sidewise. Thin strips of sheet metal, called *shims*, are placed between the connecting-rod part of the box and the cap, as shown at *e*. In order that oil may be properly distributed all over the bearing, oil grooves *f* are cut into the brasses, as shown. These oil grooves communicate, in the upper brass,

with the oil hole *g*, through which oil splashed up by the connecting-rod when in motion enters this brass; the oil grooves in the cap communicate with the oil scoop *h*, which in this particular case is a piece of copper tubing. The oil scoop, as the crank nears the bottom dead center, dips into oil contained in a trough beneath the crank and not only scoops up oil that passes upwards to the oil grooves of the lower brass *d*, but also splashes the oil all over the inside of the crank-case, thereby lubricating the pistons, wristpins, cam-shaft, and main bearings.

In automobile-engine work, it is now the common practice to lock positively all nuts on bolts that hold the two parts of bearings together. In this instance, locking is done by slotting the nuts *i* and passing a cotter pin *j* through the bolt and a pair of opposite slots in the nut; the slotted nuts are spoken of as *castellated nuts*. To prevent the bolts from turning while screwing the nuts on or off, the head of each bolt, in this case, is flattened on one side, and made to bear against a flat surface formed on the connecting-rod, as shown at *k*.

The two brasses of adjustable plain bearings are usually *relieved* where they butt against the shims; that is, part of the bearing surface is cut away, for instance as shown at *l*. Thus there is formed a pocket that greatly assists in distributing the oil evenly all over the brasses and journal; furthermore, as experience has shown, a bearing having brasses thus relieved is less liable to be damaged by heating due to friction than one whose brasses are not relieved.

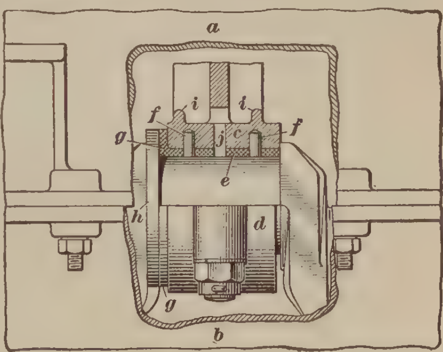


FIG. 4

7. In Fig. 4 is shown, partly in section, a common construction of a plain adjustable main bearing for an automobile-engine crank-shaft. In order to show the bearing,

part of the walls of the upper crank-case *a* and the lower crank-case *b* are broken away. The upper half *c* of the box, following the most usual construction, is cast in one with the upper crank-case; the lower half of the box, or the cap *d*, is separate and is bolted on by a bolt at each side fitted with a castellated nut that is secured by a cotter pin. Each half of the box is fitted with a removable brass, or liner, the upper one being shown in section at *e*; in this particular case, each liner is prevented from shifting by dowel-pins *f*.

The particular bearing here shown is the forward one of the two middle bearings of the four-bearing crank-shaft of a six-cylinder engine. It will be noticed that one side of each liner has formed on it a flange *g* that bears against a flange *h* of the crank-shaft. The second middle bearing has a similar flange on its liners, but on the side opposite where the flange is located on the bearing shown, and bearing against it is a crank-shaft flange similar to *h*. The crank-shaft is thus confined longitudinally. In practice, the distance between the flanges of the brasses is made a little larger than the distance between the flanges of the crank-shaft, thus permitting a little end motion of the crank-shaft to and fro, which motion greatly assists the oil distribution over the bearing and also tends to prevent it from wearing in ridges.

A great many manufacturers of automobile engines make their main bearing brasses with a flange on each side of the bearing, and omit dowel-pins, which are then not needed.

Where splash lubrication is relied on for oiling the main bearing, an oil pocket is usually formed on top of the upper half of the box; some of the oil splashed up by the connecting-rods finds its way into these pockets and is conducted to the liners and journal by an oil hole. In the illustration, the pocket is formed by two ribs *i*; the oil hole is shown at *j*.

When a main bearing is very long, as is always the case with the rear main crank-shaft bearing, there may be as many as three oil holes leading from the oil pocket to the inside. One oil hole is then placed at the middle of the bearing, and the other two are located about one-sixth the length of the bearing from its ends.

8. In some cases, one part of the main crank-shaft bearings of automobile engines is not cast integral with the crank-case, but is entirely separate therefrom and bolted in place to a partition placed crosswise and cast integral with the crank-case. An example of this kind of construction is found in the engine of the Rambler "Cross Country" car, and is illustrated in Fig. 5, the box being entirely removed from the crank-case and shown separated. The box is in two halves *a* and *b*, each of which has a rectangular opening to receive, respectively, the upper brass *c* and the lower brass *d*. When assembled over the crank-shaft journal, the two halves of the box are bolted to a cross-partition of the crank-case. The two brasses are adjustable in respect to the journal, each brass having an inclined face, as *c′*, for instance, against which bears one face of a wedge *e*, the other face of the wedge having a bearing in the box. Each wedge has two studs; by turning the nuts *f* the brasses can be brought closer together or slackened. The method provided for the adjustment of the boxes shown in Fig. 5 is very convenient, but it is very rarely encountered in practice. In nearly all cases where adjustable plain bearings formed separate from the crank-case are employed, adjustment is made by placing shims between the brasses or by removing shims. The two halves of the box are then rigidly bolted together, so that they virtually form a solid box.

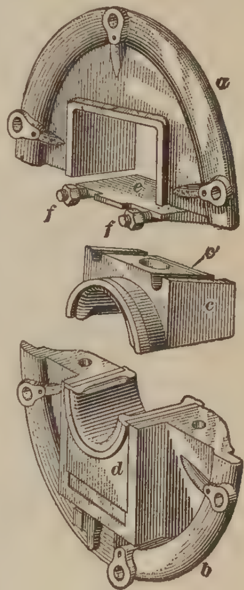


FIG. 5

SWIVEL BEARINGS

9. There are a number of places about an automobile where the yoke-and-eye-rod bearing, described in Art. **3**, cannot be used, because it permits of motion in only one plane. Where the bearing is required to permit motion in different directions,

a **swivel bearing** is used. The most prominent example of parts requiring a swivel bearing is the reach rod running from the steering-gear arm to the steering-knuckle arm; the first arm swings in a vertical plane and the second arm in a plane that is practically horizontal. Other examples are found in the control rods joining the throttle lever to the carbureter throttle, and the spark lever to the spark-advance-and-retard mechanism. In some cases, swivel bearings are also found on brake connections, and quite frequently on radius rods for rear axles, and to a slight extent, on front-axle radius rods. The case last mentioned is virtually confined to the model T Ford car, which uses a cross-spring in front and hence needs radius rods for the front axle.

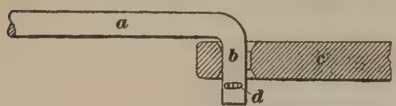


FIG. 6

10. The simplest form of swivel bearing is that shown in Fig. 6, which bearing is used considerably in popular-priced cars, on account of its low cost, for throttle and spark control rods. The round control rod *a* is bent at right angles at each end, the bent end *b* forming a journal that has a bearing in a hole drilled in the end of the lever *c*, which may be the carbureter throttle lever, a lever on the timer, the lever on the magneto breaker box, etc. To permit a limited motion in all directions, the hole in *c* is drilled somewhat larger than the end *b* and is *counter-sunk* at both sides; that is, tapered, as shown. The joint is prevented from coming apart by a cotter pin *d* passed through the end *b*. Sometimes a washer is placed on both sides of the lever *c* and around the journal *b*. The form of swivel bearing here illustrated is non-adjustable for wear; consequently, when wear occurs there will be considerable lost motion between the throttle lever or spark lever and the carbureter throttle lever or timer lever or magneto breaker-box lever that cannot be taken up without using control rods larger in

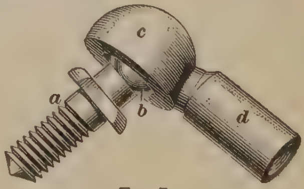


FIG. 7

diameter and reaming out the holes in the levers to which the control rods connect.

11. A form of swivel bearing for carbureter and spark control better than that shown in Fig. 6 is illustrated in Fig. 7. It is known as a *non-adjustable ball-and-socket ball joint*, and is usually made of brass. The stud *a* is fastened to the carbureter throttle lever or any similar lever, and carries a ball *b* on its end. This ball is inserted into a socket *c* having a lug *d* that is tapped out to receive the threaded control rod. The ball is prevented from coming out of the socket by spinning, or peening, the metal around the mouth of the socket down on the ball. When this swivel bearing has worn to an objectionable extent, it is supposed to be replaced with a new one.

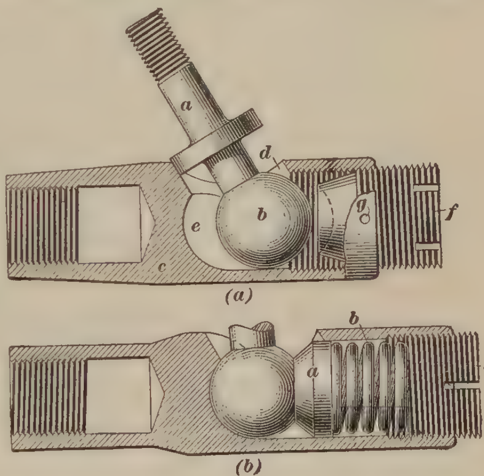


FIG. 8

12. An *adjustable ball-and-socket joint* that is used for control rods, and also occasionally for steering-gear reach rods, is shown in section, partly disassembled, in Fig. 8 (*a*). The stud *a*, with its ball *b*, is fitted to the end of the lever that is to be moved by the control rod; the socket *c* is screwed to the end of the control rod and locked with a locknut. The ball is inserted through an opening *d* in the socket and has a bearing against the spherical end *e* of the axial hole in the socket and the spherical end of the adjusting screw *f*. The outer end of the adjusting screw has three radial slots cut across it; a cotter pin passed through the hole *g* in the socket and one of the slots locks the adjusting screw, which can be turned by one-sixth of a turn in adjusting the bearing.

13. In Fig. 8 (*b*) is shown a *self-adjusting ball-and-socket joint* in which all wear is taken up automatically. This form of joint greatly resembles the one shown in (*a*). It has a follower *a* hollowed out to fit the ball, and a strong helical spring *b* is placed between this follower and the adjusting screw *c*. The spring always keeps the follower in contact with the ball and the latter in contact with the spherical part of the socket. The adjusting screw is kept locked by a cotter pin passed through a hole in the socket and one of the slots in the outer end of the screw. This form of ball-and-socket joint is largely used for the steering-gear reach rod, there being one at each end.

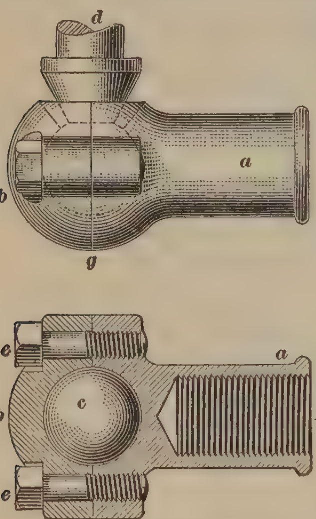


FIG. 9

14. In some self-adjusting ball-and-socket joints, there is a follower on each side of the ball and a strong helical spring behind each follower. Such a joint is sometimes used on the steering-knuckle steering arm, in which case it acts as a shock absorber, preventing road shocks from being transmitted to the steering gear.

In the smaller sizes, say for $\frac{1}{4}$-inch control rods, self-adjusting ball-and-socket joints are used for carbureter and spark advance connections on most of the higher-priced cars. Ball-and-socket joints as described in Arts. **12** and **13** are usually made of steel and are generally case-hardened.

15. An adjustable ball-and-socket joint that is often employed for hinging radius rods to the frame of the car is shown in Fig. 9. The socket is made in two parts *a* and *b*, each of which has a hemispherical depression machined therein to fit the ball *c* formed on the one end of the stud *d*, which is fastened to the side member of the frame of the car. The two halves of the socket are held together either by capscrews *e* or

by stud bolts and nuts. Adjustment is made either by placing shims between the two halves of the socket or by filing the joint *g* so as to let the two halves come closer to the ball. The part *a* of the socket is usually threaded, as shown at *f*, to receive the radius rod, which then can be adjusted for length by screwing it into or out of the socket. When adjusted for length, the radius rod and the socket are locked together by setting a lock-nut tightly against the socket. In some cases the radius rod is not adjustable for length, but is brazed into the one part of the socket; or, one part of the socket is formed integral with the radius rod.

PLAIN THRUST BEARINGS

16. A bearing so constructed as to resist a thrust in the direction of the length of its journal is called a **thrust bearing.** In its simplest form, it consists of a shoulder of some part fastened to the shaft butting against a corresponding shoulder of the box, although a hardened-steel washer or a fiber washer may be interposed between the two shoulders for the purpose of reducing friction and preventing the cutting of the shoulders under a great thrust. A bearing thus constructed is called a *plain thrust bearing*, and in automobile work is usually found in steering knuckles. However, in the model T Ford car, a plain thrust bearing is used at both sides of the differential housing inside the rear-axle tube, a fiber washer being interposed between each side of the differential housing and a flange of the axle housings, in which are placed the inner roller bearings on which the inner ends of the two halves of the axle shaft rotates. These bearings take the endwise thrust produced by the action of the large bevel gear and pinion, and by the side pressure on the wheels when turning corners.

In front axles, the weight of the car rests on the steering knuckles, the thrust being in line with the steering spindle bolt. This thrust is resisted by the one end of the steering knuckle butting against a jaw of the front axle, a washer of hardened steel, and sometimes several washers, being interposed between the two surfaces taking the thrust when a plain thrust bearing is employed.

MATERIALS FOR PLAIN BEARINGS

17. In automobile work, the journal of bearings as a general rule is of steel; often it is hardened and tempered, or *heat-treated*, as it is called, and finished by grinding in a grinding machine, which process makes the journal truly round, accurately to size, and very smooth. The metals used in the box are cast iron, hardened steel, phosphor-bronze, white brass, Babbitt, and, for bearings on which the load is very light, brass.

18. Cast iron, when copiously lubricated at all times, makes an excellent bearing material, especially when the journal is of hardened steel. It is open to the objection, however, that if the oil film between the cast-iron box and the steel journal is broken, owing to lack of sufficient lubrication, the cast iron will seize on the journal and both the box and the journal will be badly torn. For this reason, when cast iron is used, it is employed only in relatively unimportant bearings, where a plentiful supply of lubricant can be given; for instance, it is used in the engine of the model T Ford car for the cam-shaft boxes.

19. Hardened-steel boxes in the form of solid bushings are generally used in conjunction with hardened-steel journals. Both bushings and journals are usually ground after hardening to make them truly cylindrical. Boxes of this kind are sometimes found in very high-grade engines in the wristpin end of the connecting-rods, and in high-grade front axles in the ends of the jaws through which passes the hardened and ground spindle bolt of the steering knuckles. When well lubricated, hardened-steel boxes working in conjunction with hardened-steel journals will wear exceedingly well under pressures that would simply crush other kinds of boxes; even when indifferently lubricated, the wear is very small. This renders their use advisable for inaccessible places, and places in which lack of room demands a non-adjustable plain bearing of very great durability. The only reason against a more general adoption of hardened-steel boxes in places where they can be used is their high first cost.

20. Phosphor-bronze, made according to the specifications of the Society of Automobile Engineers, is an alloy containing approximately 80 per cent. of copper, 10 per cent. of lead, 10 per cent. of tin, and a quantity of phosphorus not exceeding one-quarter of 1 per cent., nor less than five one-hundredths of 1 per cent. This bearing metal stands up very well under heavy loads and lasts well even under scanty lubrication. In automobile engines, it is used considerably for both cam-shaft and wristpin bearings and in other places where it may be in contact with a hardened-steel journal. The use of phosphor-bronze boxes in connection with soft-steel journals is inadvisable, owing to the rapid wear of the soft steel, even under ample lubrication, when this combination of box and journal exists.

21. White brass is an alloy that contains from 3 to 6 per cent. of copper, not less than 65 per cent. of tin, and from 28 to 30 per cent. of zinc. This alloy is often used for main crank-shaft bearings and for connecting-rod crank-pin bearings, giving excellent results in conjunction with soft-steel journals when generously lubricated at all times.

22. Babbitt is a trade name that covers a large range of alloys made by melting together different proportions of tin, copper, antimony, and lead. It is a very soft bearing metal, has a low melting point, and can easily be fused in an iron ladle by an ordinary fire. Babbitt is relatively cheap and quite a good antifriction metal, for which reason the better grades of it are very extensively used in automobile engines for the crank-shaft and the crankpin end of the connecting-rods, where the pressure on each bearing is relatively low. None of the Babbitt metals are suitable for wristpin bearings, because owing to their small size, the bearing pressure is very high.

For a high-grade Babbitt metal, the specifications of the Society of Automobile Engineers demand 84 per cent. of tin, 9 per cent. of antimony, and 7 per cent. of copper.

Die-cast Babbitt bearing brasses are now in extensive use; these brasses are cast in steel molds from which the air has been partly exhausted, or into which the molten metal is forced under pressure. Such brasses are interchangeable and are cast

so close to the correct shape that they require no machine work or hand fitting to the boxes; hence, their replacement when badly worn is an easy matter.

23. Brass is not used as a bearing metal in engines, transmissions, axles, etc.; when serving as a bearing metal, its use is generally incidental to the part forming the box being made of one of the many alloys containing copper, tin, zinc, and lead that are usually spoken of as brass. Thus, the bearing boxes for the carbureter throttle valve stem are usually of brass, because the carbureter body is made of brass.

ANTIFRICTION BEARINGS

CLASSIFICATION

24. In all plain bearings the bearing surfaces of the box and the journal, when either is in motion, slide upon each other. Experience has shown that the resistance to sliding, that is, *sliding friction*, is very much greater than if rotating members of a bearing can roll upon each other; in other words, *rolling friction* is very much smaller than sliding friction under the same conditions. Bearings constructed so as to have rolling friction between the journal and the box are called **antifriction bearings.** Such bearings are divided into two general classes, in accordance with the means employed to substitute rolling friction for sliding friction, namely, *roller bearings* and *ball bearings*.

25. Roller bearings may be divided into *straight roller bearings* and *tapered roller bearings*. Straight roller bearings may be subdivided into *flexible roller bearings* and *solid roller bearings*, according to whether the rollers are flexible in construction or solid. In both types, the rollers are cylindrical, or *straight*, in machine-shop parlance. Flexible, and also solid straight, roller bearings are generally adapted for radial loads only, that is, loads acting at right angles to the center line, or *axis*, of the journal; by forming the rollers with a shoulder they can be made to carry axial, or thrust, loads, that is, loads acting

in the direction of the axis of the journal. Straight roller thrust bearings, while in existence, are not used in automobile work. Tapered roller bearings have rollers that are frustums of cones and are so mounted upon hardened and ground steel bushings, called *races*, that the center lines of all the rollers lie on the surface of a right cone whose axis coincides with the axis of the journal; when this condition is fulfilled, the rollers will have a true rolling motion. A tapered roller bearing can carry both radial and axial loads.

26. Ball bearings used in automobile work can be divided into three general classes, namely, *radial ball bearings*, *radial-and-thrust ball bearings*, and *axial*, or *thrust*, *ball bearings*. Radial ball bearings, as implied by the name, are intended for radial loads, which means loads at right angles to the shaft, although they can generally resist a slight thrust load. Radial-and-thrust ball bearings can take radial and thrust loads with equal facility; they differ from combination radial-and-thrust bearings in that the two kinds of load are borne by a single bearing. Ball thrust bearings are intended entirely for axial loads, that is, thrusts in the direction of the center line of the shaft.

All ball bearings consist of at least three elements, which are the *inner race*, the *balls*, and the *outer race*. The inner race is attached to the shaft and forms the journal; the outer race is attached to the bearing housing and serves as the box; and the balls provide for rolling friction.

27. Antifriction bearings are used in automobile work for the front wheels, the rear axle and the transmission, as well as for dynamo armatures, electric starting motor armatures, magneto armatures, fans, etc., and in a very few cases they are employed for main bearings of crank-shafts.

STRAIGHT ROLLER BEARINGS

28. Flexible roller bearings are made in two styles, which are known as the standard Hyatt roller bearing and the high-duty Hyatt roller bearing. Both types of bearing embody

the principle of a flexible roller, but the first type named is intended for light radial loads, while the second type is used for heavy radial loads.

29. *A standard Hyatt roller bearing* is shown disassembled in Fig. 10. The rollers *a* are wound helically from flat steel and are ground cylindrical after hardening. They are set in a cage *b* made of two washers properly spaced by ribs *c*, to which the washers are securely riveted. Projections *d* on each washer enter the ends of the rollers and thus prevent them from falling out of the cage. The rollers are sometimes run directly on the journal and the box of the bearing; in better work, both the

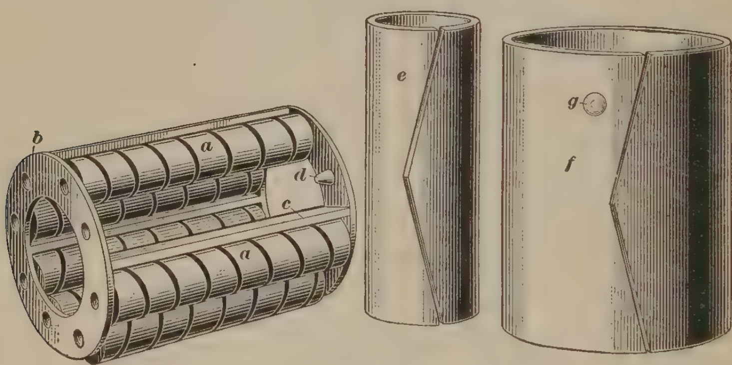


FIG. 10

journal and the box are protected by removable liners. A liner for the journal is shown at *e*, and a liner for the box at *f*. These liners are formed from soft-sheet steel, and since they are split as shown, they are easily forced into place or removed when worn enough to need replacement. The outer liner should be held from turning in the box by making the conical projection *g* enter a hole drilled for this purpose into the box. A liner for the journal is often omitted; when the metal of the journal is very soft, however, a case-hardened steel liner is necessary. This liner may have the form shown in *e* or it may be in the form of a solid bushing that is pressed on the journal. Likewise, the outer liner may be in the form of a solid bushing.

30. The *high-duty Hyatt roller bearing* differs from the standard bearing in that another brand of steel is used for the rollers, making them suitable for higher loads, and also in that a somewhat different form of cage is used, as shown in Fig. 11. It also differs from the standard bearing in that the liners, if any are used, are made in the form of thick, solid bushings that have been carefully ground inside and outside after hardening. Liners are used only when the journal and the box are of soft material. When the box is of hardened steel, no outer liner is used, and when the journal is of hardened steel no inner liner is employed. The liners are often called the *inner* and *outer races.*

The cage of this high-duty bearing is made of two washers *a* properly spaced by distance rods *b*, there being a distance rod between each pair of rollers, so that they can never come in contact with each other. In the standard bearing cage, as reference to Fig. 10 will show, there are two rollers between each pair of distance ribs, at *c*; consequently, the two rollers of each nest will be in contact when the journal is rotating.

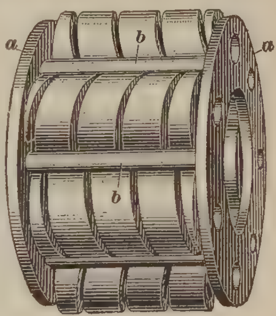


FIG. 11

When either an inner or an outer race, or both, are used, the race or races are supposed to be held from rotating on their seats either by pressing them tightly into place or by locking them in some convenient manner.

31. The object in putting the rollers in a cage in any roller bearing is to prevent them from twisting out of position, as they can be in contact with the journal or the box throughout their whole length only when the center line of each roller is in the same plane with the center line of the bearing.

32. In Fig. 12 is shown a *Norma roller bearing*, in which a series of cylindrical rollers *a* run between a cylindrical inner race *b* and a slightly curved outer race *c*. This curved bearing face of the outer race permits this form of bearing to undergo slight errors of alinement without undue stresses on the rollers

or races; such errors may result from faulty mounting of the races or from bending the shaft on which the inner race is mounted. The rollers are caged between two rings *d* and *e* and are mounted on pivot pins *f* fastened to these two rings. A locking ring *g* locks the cage together, it being slotted, as shown at *g′*, to pass over a groove *f′* turned in each pivot pin. The rollers and races are of hardened and ground steel.

The Norma bearing differs from the Hyatt bearing chiefly in that the rollers are in the form of solid bushings.

33. Neither the Hyatt nor the Norma roller bearing, nor any other bearing of this type, is suitable for any other than a

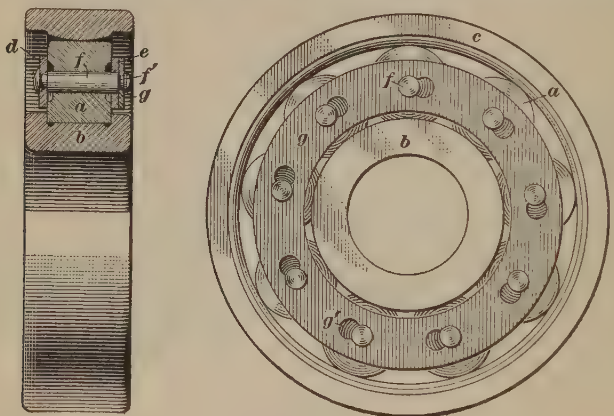


FIG. 12

radial load. When an axial or a thrust load comes on such a bearing, this load must be taken by a separate thrust bearing of either the plain or the antifriction type. By using a special form of roller, however, in conjunction with a special form of race, a cylindrical roller bearing can be made to carry an axial load in one direction. The *Bower roller bearing*, which is shown in Fig. 13, is a bearing capable of carrying both radial and axial loads.

In view (*a*) one of the rollers of the Bower bearing is shown in perspective. It consists of a cylindrical part *a* that carries the radial load, an enlarged part *b* in the form of two frustums of cones, and two pivots *c* that pass through holes in the side

rings of the cage when the bearing is assembled and thus confine each roller.

A section through a Bower bearing is shown in (*b*). The outer race *a* has an enlarged bore at one side and a conical shoulder *b*; the inner race *c* is grooved and has a conical shoulder *d*. A thrust load in the direction of the arrow *e* is taken

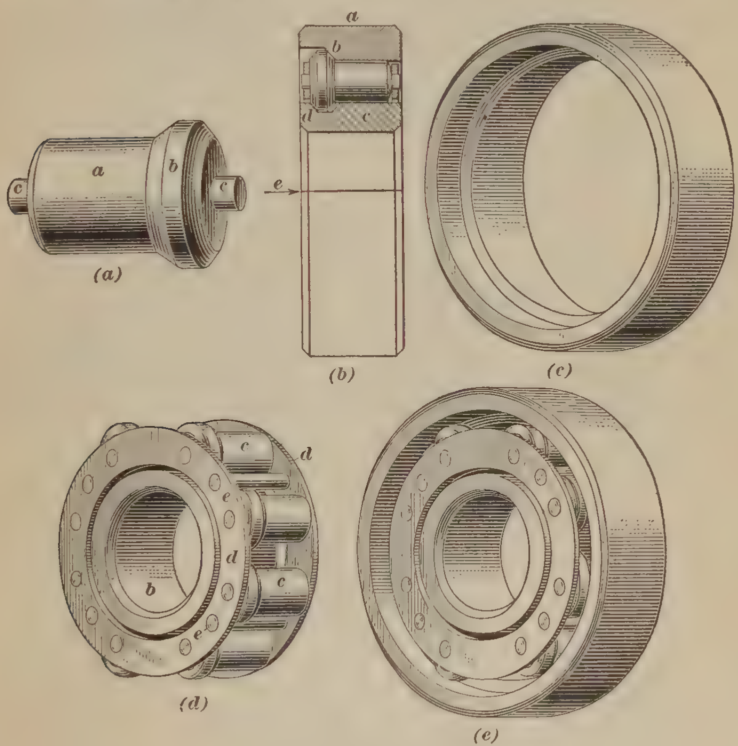


Fig. 13

by the shoulders *b* and *d* of the inner and outer races and the conical surfaces of the enlarged end of the roller.

In view (*c*), the outer race *a* is shown in perspective, and in view (*d*) the inner race *b* and the rollers *c* in their cage are shown assembled. The cage is composed of two rings *d* properly spaced and held together by the distance pieces *e*. The complete assembled bearing is shown at (*e*).

Like all other cylindrical roller bearings, the Bower bearing is non-adjustable radially, excellence of material and workmanship being relied on to prevent undue wear and subsequent looseness. Replacement of worn parts is easily effected.

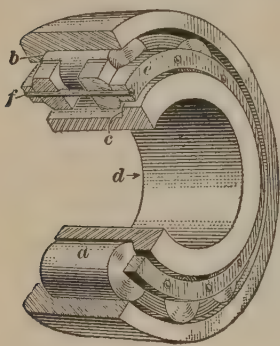


FIG. 14

34. The *Standard roller bearing*, shown in perspective and partly in section in Fig. 14, employs cylindrical rollers *a* with conical ends. The outer race is formed with a conical shoulder *b*, and the inner race has a conical shoulder *c*. The radial load is carried by the cylindrical part of the rollers and races, and an axial load in the direction of the arrow *d* is carried by the shoulders *b* and *c* and the conical ends of the rollers. The rollers are confined by being set in pockets formed in the cage *e*, which is composed of rings held together by rivets *f*.

TAPERED ROLLER BEARINGS

35. **A tapered roller bearing,** as implied by the name, employs tapered rollers, that is, rollers that are frustums of cones, running in contact with tapered inner and outer races. The most widely used bearing of this form, in automobile work, is the *Timken roller bearing*, which is shown in Fig. 15. In (*a*) is shown a section through the inner and outer race with a roller *a* between the conical (tapered) surfaces of the inner race *b* and the outer race *c*. The inner race is cylindrical on its inside, and the outer race on its outside. The inner race has two ribs with conical sides, the rib *d* entering a corresponding groove *e* in the small end of the roller *a*. The conical face of the rib *f* bears against the conical large end of the roller, as shown. The ribs *d* and *f*, in conjunction with a cage in which the rollers are set, hold the rollers in proper alinement with the races. The cage is shown separately at (*b*); it is pressed in one piece from sheet steel into the form shown. The inner race is shown in

perspective in view (*c*), and assembled with the cage and rollers, in (*d*). When thus assembled, the inner race, cage, and

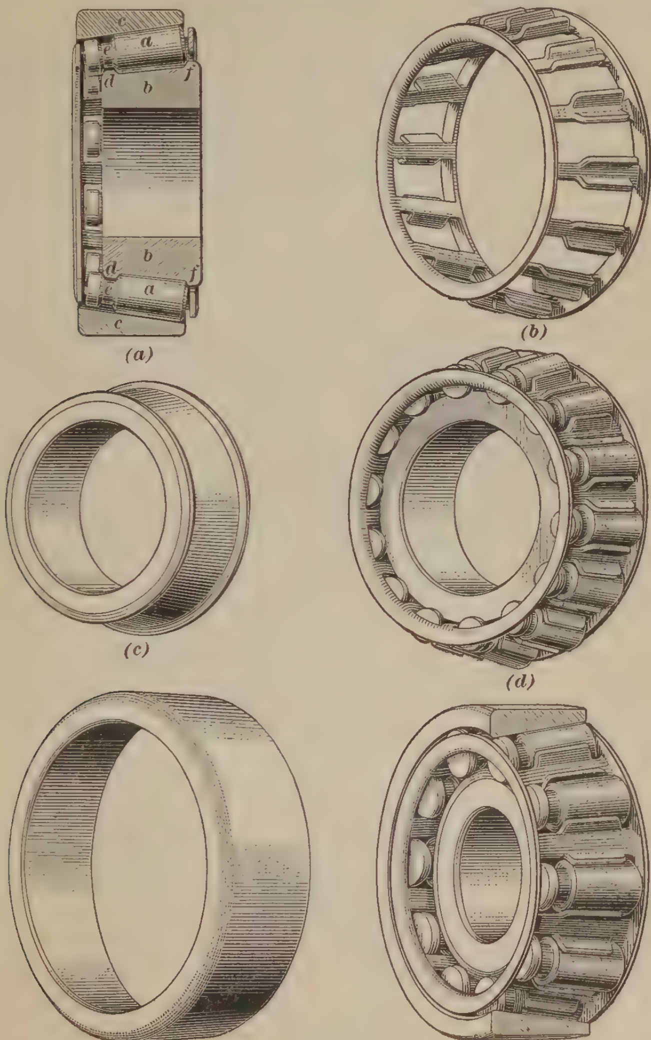
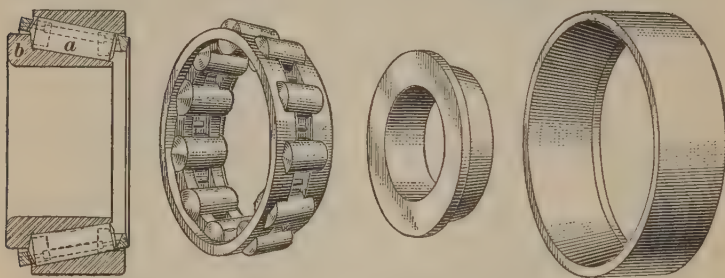


Fig. 15

rollers cannot separate. The outer race is shown separately in (*e*), and the whole bearing assembled in (*f*).

The outer and inner races have their bearing surfaces formed as frustums of cones whose apexes coincide and lie on the center line of the journal; the center lines of the rollers lie on the surface of a cone whose apex coincides with that of the inner and outer races, and consequently the rollers have a true rolling motion. As in cylindrical roller bearings, the cage for the rollers prevents their sidewise displacement.

A tapered roller bearing carries radial and axial loads, and any radial looseness due to wear is readily taken up by forcing the inner race farther into the outer race. This form of bearing is always mounted so as to permit this operation to be



(a) (b) (c) (d)

Fig. 16

easily done. The races and rollers are made of hardened steel and are very accurately ground after hardening. Tapered roller bearings are largely used in the construction of rear axles.

36. The improved *Grant roller bearing*, made by the Standard Roller Bearing Company, is shown in Fig. 16. The tapered rollers *a*, as shown in the sectional view (*a*), are not grooved and their conical large end bears against a conical shoulder *b* of the inner race. The outer race is tapered inside and cylindrical outside. The rollers are set in pockets formed in a two-part steel cage, the two parts of which are held in place by stayrods, after the rollers have been assembled into the cage, as shown in view (*b*). A perspective view of the inner race is shown in (*c*), and of the outer race in (*d*). This roller bearing consists of three separate structures, namely, the inner race, the outer race, and the cage with its rollers.

RADIAL BALL BEARINGS

37. Radial ball bearings are divided into two general types: the *full ball bearing* and the *silent ball bearing*. Each type may have a single row of balls, when it is called a *single-row ball bearing*, or it may have several rows of balls, when it is called a *multiple row-ball bearing*. In present automobile work, a radial ball bearing with more than two rows of balls is hardly ever found. Radial ball bearings are often spoken of as *annular ball bearings*, there being an annular space between the inner and the outer race, which space contains the balls.

38. A full-type annular ball bearing with a single row of balls, as made by the Standard Roller Bearing Company, is shown in Fig. 17 (*a*), in which illustration part of the outer race *a* is cut away in order to show the assembly. The outer race *a* and the inner race *b* are grooved to a larger radius than that of the balls *c* in order that the balls may be in contact with each race at a single point in the same plane as the centers of the balls. The balls are introduced between the races through a slot in the outer race, which slot cannot be seen in view (*a*), but is indicated at *d* in the cross-section shown in (*b*).

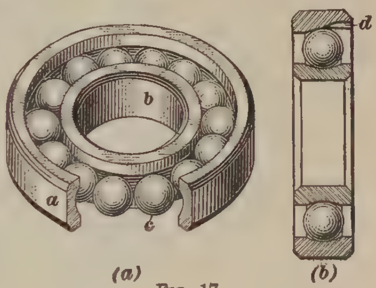


Fig. 17

39. In all full-type annular ball bearings, which derive their name from the fact that the annular space between the two races is filled with balls, some means must be provided for getting the balls into place. In some bearings of this type the outer race is slotted and the slot left open; in others the slot is closed by a filling piece; and in yet another form the balls are introduced through a radial hole in the outer race, which hole is afterwards closed by a hardened-steel plug that is prevented from coming out by the housing into which the outer race is forced. In still another form of annular bearing

of the full type, the outer race is made cylindrical, only the inner race being grooved; consequently, the outer race can be slipped in place after all the balls are placed in the groove of the inner race. This form of bearing, which was used at one time in the engines and also in the rear axles of White cars, is

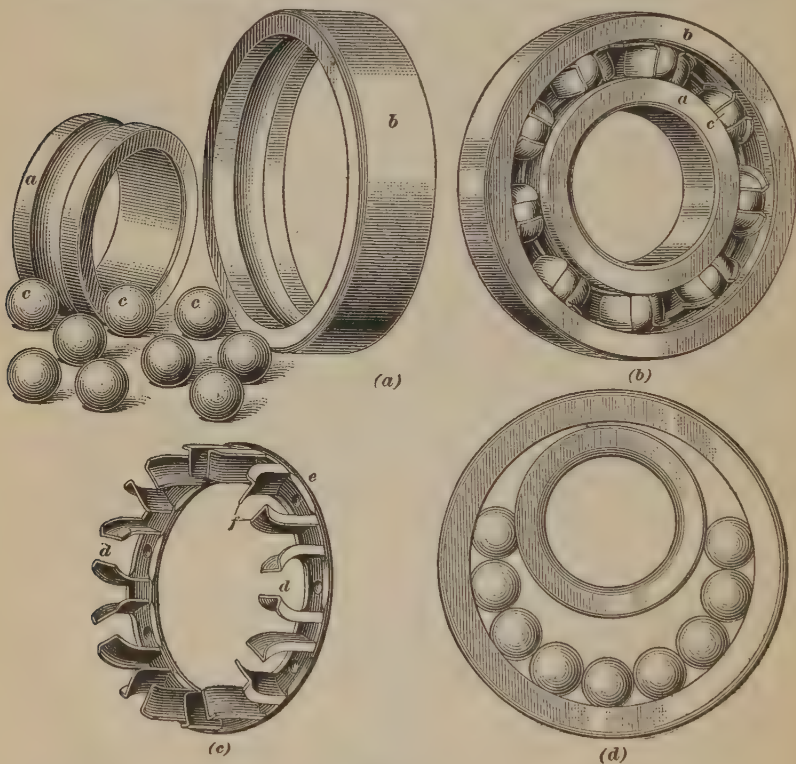


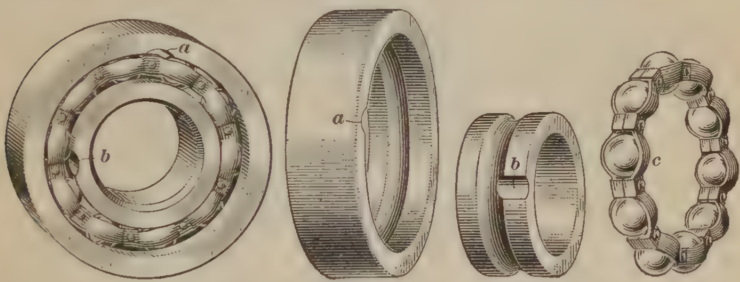
Fig. 18

not a self-contained unit; that is, the inner and outer races and balls will easily come apart when either race is removed from its seat.

40. Annular ball bearings of the silent type have their balls set in cages, so that they cannot come in contact with each other. They derive their name from the absence of the clicking sound, caused by the balls striking against each other,

that is found in ball bearings of the full type. Silent-type annular bearings are made by many different firms, the various makes differing from each other chiefly in the form of cage that is employed.

41. Fig. 18 illustrates the silent annular bearing made by the Hess-Bright Company and known as the *H B—D W F bearing*. In view (*a*) is shown the bearing before it is assembled, and in (*b*), the completely assembled bearing. View (*c*) shows the cage that confines the balls. The same parts are lettered alike in these views. The bearing is of the single-row type. The inner race *a* is cylindrical inside and is grooved outside to a radius equal to the ball diameter, as is also the outer race *b*. The balls *c* are set in pockets *d* of the cage *e*. This bearing is



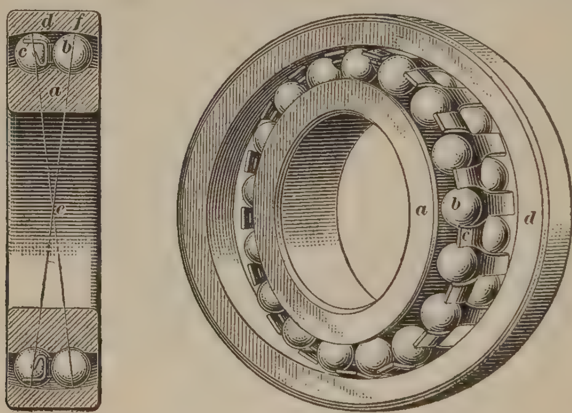
(a) (b)

Fig. 19

distinguished from many other silent types of ball bearings in that the balls can be and are introduced between the races without either one of them having a filler slot; that is, the grooves of the races are continuous. The pockets in the cage *e* consist of **U**-shaped sheet-brass stampings, the legs *f* of which are substantially straight and parallel before assembly of the bearing.

To assemble the bearing, the inner race is inserted eccentrically in the outer race and the proper number of balls are dropped between the races, as is indicated in (*d*). The balls are then spaced equidistantly, and the cage is put in place so that a ball sits in each pocket. The free ends of the legs *f* are then bent over the balls, which operation assembles the bearing into a unit of which the component parts cannot come apart.

42. Whether or not an annular silent type ball bearing that forms a unit when assembled must have filler slots cut in the races is determined solely by the number of balls the manufacturer has decided to use between the races. When a large number of balls are used, the bearing must have filler slots in its races; sometimes the outer race has a filler slot, sometimes the inner race has such a slot, and sometimes both races have these slots. An example of the latter type is the *New Departure single-row annular ball bearing*, which is shown assembled in Fig. 19 (*a*) and disassembled in (*b*). In the illustration the filler slot for the outer race is shown at *a* and the filler slot for



(*a*) (*b*)

FIG. 20

the inner race at *b*. The ball cage, or separator, *c* containing the balls is made in two halves and of sheet steel; the two halves are riveted together after the bearing has been assembled.

43. It is possible to design an annular ball bearing in such a manner that it can be entirely filled with balls or be made of the silent type, just as is desired, without having filler slots in either race; such a bearing, however, will not be a unit when assembled. A well-known example of this form of bearing is the *S K F double-row self-alining ball bearing* shown in section in Fig. 20 (*a*) and partly assembled in (*b*). In both views, the same parts are lettered alike. The inner race *a* has two grooves

side by side and so spaced that the balls *b* of the two rows lie staggered in the pockets of the cage *c*. This feature can be clearly seen in view (*b*). A curvature having a radius *e f*

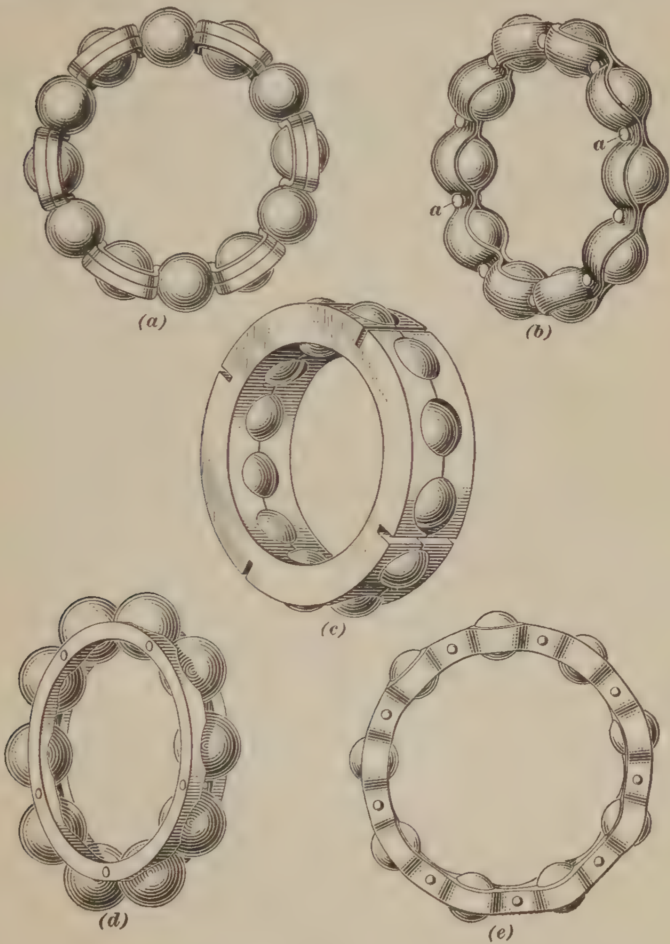


FIG. 21

struck from the center *e* of the bearing is given to the outer race *d*, and as a consequence the inner race, which is rigidly mounted on the shaft to which it is applied, can rock slightly in reference to the outer race under any springing of the shaft

without cramping the balls in any way. The cage *c* is formed from sheet steel. View (*b*) indicates how the bearing is assembled and shows that the outer race is free from the balls and the inner race when the bearing is not attached to a shaft and housing.

44. In some radial ball bearings, as, for instance, in those made by Fichtel and Sachs, and known as the *F. & S. ball bearings*, self-alinement is secured by making the outer surface of the outer race part of a sphere and seating it in a spherical seat.

45. Various forms of ball cages are used for silent annular bearings by different makers. Some of these cages have already been shown in connection with several bearings illustrated and described; several other cages are shown in Fig. 21. In order to illustrate these cages clearly, they are all shown assembled with the balls in place but removed from the two races; it must be distinctly understood that in the actual bearing the cages are assembled after the balls have been placed into the races.

Three different forms of cages used in the F. & S. annular bearings are illustrated in views (*a*), (*b*), and (*c*). The one shown at (*a*) is known as a *ribbon cage* or a *ribbon separator*, the term ball separator being sometimes used instead of the term ball cage. This ribbon cage is stamped from sheet steel and is stiffened by ribs. The sheet metal cage at (*b*) is made from two like rings pressed into shape and united by rivets *a* when the bearing is assembled. The so-called *solid cage* at (*c*) is machined from solid metal in two halves, with pockets to receive the balls, which also are machined out of the solid; the two halves are fastened together rigidly when assembling the bearing. The ball cage used in the *R. I. V. annular bearings* is shown in (*d*). It greatly resembles the cage shown in (*c*), and is also machined from the solid in two halves that are riveted together when the bearing is assembled. The cage shown in (*e*), which also is made in two halves pressed from sheet metal and riveted together when assembling the bearing, is used in the annular ball bearings made by the Standard

Roller Bearing Company. This cage differs from the one shown in view (*b*) only in that it contains fewer balls, comparing bearings of the same dimensions of the two makes, because the bearing in which it is used has no filler slots in either race.

46. Although annular ball bearings are designed primarily to carry a radial load, they can safely carry an axial load equal to about one-tenth the safe radial load. When the axial load becomes greater than is safe, this load is taken by a separate thrust bearing, which may be combined into a single unit with the radial bearing, but more frequently is entirely separate.

47. The annular type of ball bearings was developed in Europe, where the metric system of measurements is in common use, and hence was made in sizes measured in millimeters. When the manufacture of these bearings was taken up in the United States, the American makers adopted these same measurements in order that their bearings would interchange with the imported bearings, which accounts for the fact that to this day the dimensions of annular ball bearings are expressed in millimeters instead of inches.

The manufacture of single-row annular ball bearings is standardized to a large degree, so that bearings made by different manufacturers, but having the same trade number, will interchange perfectly. The single-row annular bearings in most common use are made in five series, in both the full and silent types. These series are as follows:

1. *Medium and Heavy Series, Narrow Type.*—Bearings of this series are designated by numbers that identify them, and are below 100.
2. *Light Series, Narrow Type.*—The identification numbers begin with 100 and are below 200.
3. *Light Series, Wide Type.*—The identification numbers begin with 200 and are below 300.
4. *Medium Series, Wide Type.*—The identification numbers begin with 300 and are below 400.
5. *Heavy Series, Wide Type.*—The identification numbers begin with 400 and are below 500.

The identification number is usually stamped on one of the races, and sometimes on both, and even on the ball cage. When this number is known, the series is also known; thus, if

TABLE I

SINGLE-ROW ANNULAR BALL BEARINGS, MEDIUM AND HEAVY SERIES, NARROW TYPE

No. of Bearing	Inside Diameter		Outside Diameter		Width	
	Inches	Millimeters	Inches	Millimeters	Inches	Millimeters
1	.4724	12	1.4567	37	.3543	9
2	.5905	15	1.5748	40	.3543	9
3	.7874	20	2.0472	52	.3937	10
4	.9843	25	2.4409	62	.4724	12
5	1.1811	30	2.8346	72	.5118	13
6	1.3780	35	3.1496	80	.5512	14
7	1.5748	40	3.5433	90	.6299	16
8	1.7717	45	3.9370	100	.6693	17
9	1.9685	50	4.3307	110	.7480	19
10	2.1653	55	4.6063	117	.7480	19
11	2.3622	60	5.0000	127	.7874	20
12	2.5591	65	5.3937	137	.8661	22
13	2.7559	70	5.7874	147	.9449	24
14	2.9528	75	6.1811	159	.9843	25
15	3.1496	80	6.6141	168	1.0630	27
52	.7874	20	2.5591	65	.5512	14
53	.8661	22	2.8346	72	.6299	16
54	.9843	25	3.1496	80	.6693	17
55	1.0630	27	3.4645	88	.7480	19
56	1.1811	30	3.7402	95	.7874	20
57	1.3780	35	4.0551	103	.8661	22

an annular ball bearing is stamped 308, it belongs to the medium series, wide type.

The identification numbers and sizes of the most common single-row annular ball bearings are given in Tables I to V, the sizes being given in both millimeters and inches.

48. Although the practice of designating annular single-row ball bearings by the numbers here given is commonly followed, there are exceptions. Thus, the New Departure

TABLE II

SINGLE-ROW ANNULAR BALL BEARINGS, LIGHT SERIES, NARROW TYPE

No. of Bearing	Inside Diameter		Outside Diameter		Width	
	Inches	Millimeters	Inches	Millimeters	Inches	Millimeters
102	.3937	10	1.2598	32	.3543	9
103	.5905	15	1.4567	37	.3543	9
104	.7874	20	1.6535	42	.3543	9
105	.9843	25	2.0472	52	.3543	9
106	1.1811	30	2.4409	62	.3937	10
107	1.3780	35	2.7559	70	.3937	10
108	1.5748	40	3.1496	80	.4331	11
109	1.7717	45	3.3465	85	.4331	11
110	1.9685	50	3.5433	90	.4331	11
111	2.1653	55	3.9370	100	.4724	12
112	2.3622	60	4.1339	105	.4724	12
113	2.5591	65	4.5275	115	.5512	14
114	2.7559	70	4.7245	120	.5512	14
115	2.9528	75	5.1182	130	.6299	16
116	3.1496	80	5.3149	135	.6299	16
117	3.3465	85	5.7086	145	.7087	18
118	3.5433	90	5.9056	150	.7087	18
119	3.7402	95	6.2992	160	.7874	20
120	3.9370	100	6.4960	165	.7874	20
121	4.1339	105	7.0867	180	.8661	22
122	4.3307	110	7.2834	185	.8661	22

bearings of this type have the figure 1 prefixed to the trade numbers given in Tables I to V. For instance, the New Departure bearing having the number 1404 has an inside diameter of 20 millimeters, an outside diameter of 72 milli-

meters, and a width of 19 millimeters, which are the same dimensions as those of bearing No. 404 in Table V. No confusion arises in practice from these differences of numbering when a bearing is to be replaced by one of the same number

TABLE III

SINGLE-ROW ANNULAR BALL BEARINGS, LIGHT SERIES, WIDE TYPE

No. of Bearing	Inside Diameter		Outside Diameter		Width	
	Inches	Millimeters	Inches	Millimeters	Inches	Millimeters
204	.7874	20	1.8504	47	.5512	14
205	.9843	25	2.0472	52	.5905	15
206	1.1811	30	2.4409	62	.6299	16
207	1.3780	35	2.8346	72	.6693	17
208	1.5748	40	3.1496	80	.7087	18
209	1.7717	45	3.3465	85	.7480	19
210	1.9685	50	3.5433	90	.7874	20
211	2.1653	55	3.9370	100	.8268	21
212	2.3622	60	4.3307	110	.8661	22
213	2.5591	65	4.7244	120	.9055	23
214	2.7559	70	4.9213	125	.9449	24
215	2.9528	75	5.1181	130	.9843	25
216	3.1496	80	5.5118	140	1.0236	26
217	3.3465	85	5.9055	150	1.1024	28
218	3.5433	90	6.2992	160	1.1811	30
219	3.7402	95	6.6929	170	1.2598	32
220	3.9370	100	7.0866	180	1.3386	34
221	4.1339	105	7.4803	190	1.4173	36
222	4.3307	110	7.8740	200	1.4961	38

and of the same make; when it is to be replaced by one of a different make, either the maker or his catalog is consulted for the trade order number.

It must not be inferred that only the bearings given in Tables I to V are manufactured; smaller or larger bearings can be

obtained in the five series, either on regular or special order, and special sizes to suit special conditions are also manufactured.

TABLE IV

SINGLE-ROW ANNULAR BALL BEARINGS, MEDIUM SERIES, WIDE TYPE

No. of Bearing	Inside Diameter		Outside Diameter		Width	
	Inches	Millimeters	Inches	Millimeters	Inches	Millimeters
300	.3937	10	1.3780	35	.4331	11
301	.4724	12	1.4567	37	.4724	12
302	.5906	15	1.6535	42	.5118	13
303	.6693	17	1.8504	47	.5512	14
304	.7874	20	2.0472	52	.5905	15
305	.9843	25	2.4409	62	.6693	17
306	1.1811	30	2.8346	72	.7480	19
307	1.3780	35	3.1496	80	.8268	21
308	1.5748	40	3.5433	90	.9055	23
309	1.7717	45	3.9370	100	.9843	25
310	1.9685	50	4.3307	110	1.0630	27
311	2.1653	55	4.7244	120	1.1417	29
312	2.3622	60	5.1181	130	1.2205	31
313	2.5591	65	5.5118	140	1.2992	33
314	2.7559	70	5.9055	150	1.3780	35
315	2.9528	75	6.2992	160	1.4567	37
316	3.1496	80	6.6929	170	1.5354	39
317	3.3465	85	7.0867	180	1.6142	41
318	3.5433	90	7.4803	190	1.6929	43
319	3.7402	95	7.87[illegible]	200	1.7717	45
320	3.9370	100	8.4640	215	1.8504	47
321	4.1339	105	8.8583	225	1.9291	49
322	4.3307	110	9.4488	240	1.9685	50

Neither does each manufacturer necessarily make all five series of annular single-row ball bearings.

In a very few instances, automobile manufacturers have made their own annular bearings to their own standards; such bearings, for replacement purpose, must as a general rule be obtained from the proper automobile manufacturer.

49. All annular ball bearings are non-adjustable; they are properly assembled at the factory and are intended to be

TABLE V

SINGLE-ROW ANNULAR BALL BEARINGS, HEAVY SERIES, WIDE TYPE

No. of Bearing	Inside Diameter		Outside Diameter		Width	
	Inches	Millimeters	Inches	Millimeters	Inches	Millimeters
403	.6693	17	2.4409	62	.6693	17
404	.7874	20	2.8346	72	.7480	19
405	.9843	25	3.1496	80	.8268	21
406	1.1811	30	3.5433	90	.9055	23
407	1.3780	35	3.9370	100	.9843	25
408	1.5748	40	4.3307	110	1.0630	27
409	1.7717	45	4.7245	120	1.1417	29
410	1.9685	50	5.1181	130	1.2205	31
411	2.1653	55	5.5119	140	1.2992	33
412	2.3622	60	5.9055	150	1.3780	35
413	2.5591	65	6.2992	160	1.4567	37
414	2.7559	70	7.0867	180	1.6535	42
416	3.1496	80	7.8740	200	1.8898	48
418	3.5433	90	8.8583	225	2.1260	54
420	3.9370	100	10.4331	265	2.3622	60

replaced with new ones when worn to an objectionable degree. In many cases, worn annular ball bearings can be repaired, however, at small cost, either at the factory where they were made or at establishments specializing on this class of repair work. The repair is effected by regrinding both races and

substituting larger balls; owing to the special machinery and the high degree of workmanship required, this work cannot be done in garages or ordinary machine shops, but must be done by specialists.

The great success that has been obtained with annular bearings is in a large degree to be attributed to their non-adjustability, which feature prevents their overloading by a wrong adjustment.

RADIAL-AND-THRUST BALL BEARINGS

50. The earliest form of ball bearing suitable for combined radial and thrust loads was developed in the early days of the bicycle industry, and from the form of its races it is called the *cup-and-cone ball bearing*. Such a bearing is shown in cross-section in Fig. 22, the one illustrated being the inside front-wheel bearing used in the Maxwell "25" car. Bearings of the type illustrated are not regularly on the market, but are either made by the automobile manufacturer himself or to his order.

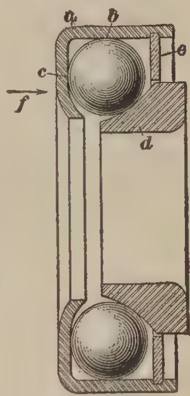


FIG. 22

The *cup a* forming the outer race is so shaped that it comes in contact with each ball at two points, as at *b* and *c*; the *cone d* forms the inner race and is in contact with each ball at a point. There are thus three points of contact for each ball, whence the name *three-point ball bearing* is derived. A groove is turned in the outer race, into which is sprung a split retainer ring *e*, the purpose of which is to retain the balls in the cup when the cone is removed. This bearing can carry a thrust load in only one direction, which is indicated by the arrow *f*. The cone in this particular case is the stationary member of the bearing, and the cup the movable member; but in other cases the cup is the stationary member.

With the ordinary cup-and-cone ball bearing, it is customary to fill the space between the cup and the cone with as many balls as it will hold; that is, to make it a full-type bearing.

51. The application of the cup-and-cone type of bearing to the front wheel of the Maxwell "25" car is shown in Fig. 23, in which *a* is the steering-knuckle spindle formed integral with the steering knuckle. The inside bearing is shown at *b* and the outside bearing at *c*. The cups of both bearings are pressed into the hub *d* of the front wheel; the cone of the inside bearing is pressed on the spindle *a* against a shoulder formed thereon. The cone *e* of the outside bearing is threaded internally to fit a thread of the spindle, and by turning it in or out the two bearings are adjusted. After adjustment the cone *e* is locked in place by a locknut *f* of the castellated type and a washer *g*. This washer is prevented from rotating by a lug that is formed integral with it entering a longitudinal slot cut into the threaded part of the spindle. Rotation of the cone *e* while setting up the locknut is thus prevented by this washer *g*. The castellated locknut *f* is positively locked to the spindle by the cotter pin *h* passing through a slot of the nut and through the spindle. The steering knuckle shown is of the reversed Elliott type, that is, the spindle and yoke are one piece and the end of the axle bar is pivoted in the yoke.

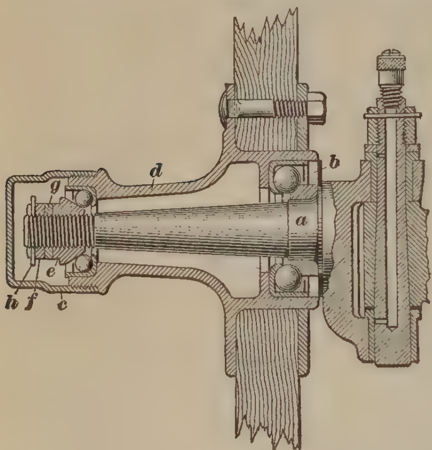


Fig. 23

On first thought it would appear that the wear of the cups, cones, and balls could be readily compensated for in cup-and-cone ball bearings by adjusting the one cone. This is not possible, however, except to a very slight degree, because the cones wear out of round, a groove being formed on the loaded side, which groove is deepest at the point where the load is greatest.

A pair of cup-and-cone ball bearings combined, as in Fig. 23, gives an assembly that will resist thrust in opposite directions.

52. A radial-and-thrust ball bearing made by the New Departure Manufacturing Company under the name of the *Radax ball bearing*, which takes thrust loads in only one direction, is shown in Fig. 24. The bearing is of the two-point contact, silent type, being fitted with a ball separator. In (*a*) the bearing is shown in section, the balls being in contact with the inner race *a* at *b*, and with the outer race *c* at *d*. At *e* the separator is shown in section. The races are so made that the

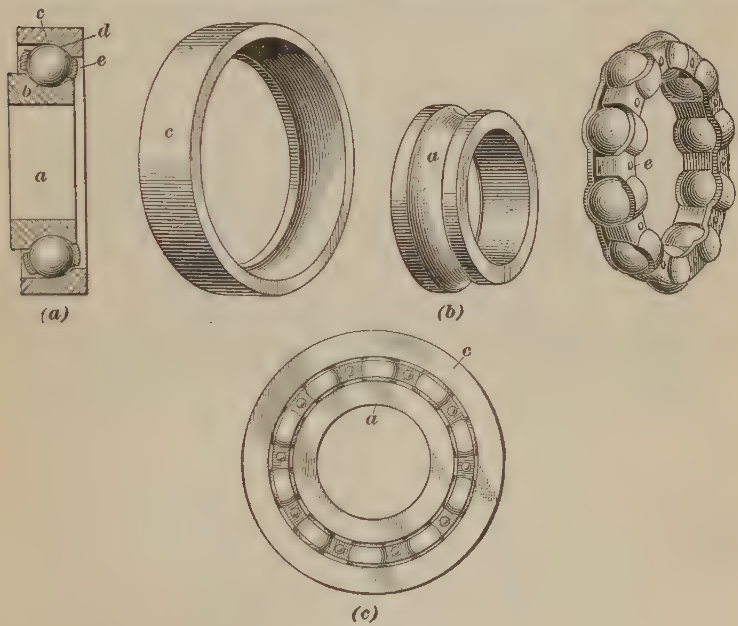


FIG. 24

two points of contact of each ball lie on a cone whose apex is on the center line of the journal; under this condition the balls have a true rolling motion. In view (*b*) are shown in perspective the inner race *a* and the outer race *c* and also the separator *e* with the balls in place. The separator is made of steel and in two parts, which are riveted together after the balls and separator have been assembled over the inner race; the separator, balls, and inner race are then a unit. In (*c*) the bearing is shown completely assembled.

Radax bearings are made to interchange with standard radial annular bearings.

53. The *New Departure double-row ball bearing* shown in Fig. 25 is intended for combined radial and thrust loads, and can take thrusts in opposite directions. It greatly resembles two Radax bearings assembled back to back into a single structure. In (*a*) the bearing is shown in perspective, but partly in section, and in (*b*) the complete assembled bearing is shown. In (*c*) a cross-section of the bearing is given. The same parts are lettered alike in the three views. The inner

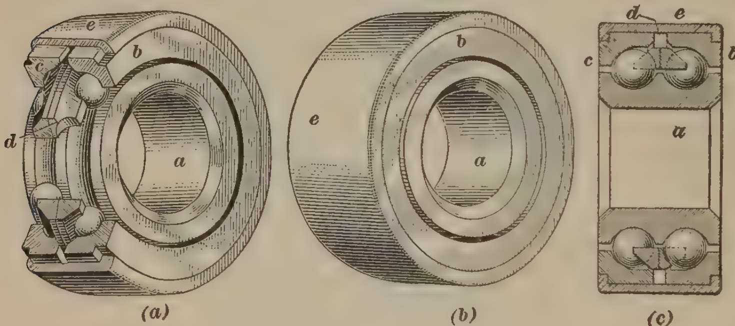


Fig. 25

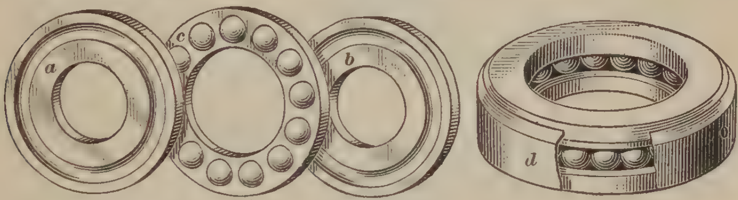
race *a* is solid and has two grooves, or raceways, so laid out that each ball makes contact with it at only one point. There are two separate outer races *b* and *c*, which are also made so that each ball touches them at only one point; hence, each inner and outer raceway, together with their balls, form a two-point bearing. The balls are placed in a manganese-bronze separator *d* made in two halves. The whole bearing is assembled into a single unit by spinning a steel shell *e* over the outer races. After the shell has been spun over, its outside is ground perfectly concentric with the bore of the bearing. It is obvious that this double-row bearing is non-adjustable, although the wear may be taken up by putting in larger balls. The success obtained in practice from this form of bearing is largely due to its non-adjustability.

New Departure double-row ball bearings are made to the same dimensions, so far as inside and outside diameters are concerned, as standard radial annular ball bearings; they are much wider, however.

BALL THRUST BEARINGS

54. In automobile work are used two forms of ball thrust bearings that may be classified as *plain* and *self-alining thrust bearings*. Either class may belong to the silent or the full type of bearing.

55. A plain ball thrust bearing of the silent type, as made by the Standard Roller Bearing Company, is shown completely disassembled in Fig. 26 (*a*). It consists of two grooved hard-



(*a*) (*b*)

Fig. 26

ened-steel races *a* and *b*, between which is placed the ball cage *c* containing the balls. In the full type, no cage is employed. Both the full and silent types are sometimes assembled with a retaining band *d* around them, as shown in view (*b*), so that the races and balls cannot come apart when the bearing is removed from its place. In the plain ball thrust bearing, careful machining of the seats for the two races is relied on to distribute the thrust load evenly over all the balls; it is evident, however, that the slightest springing of shaft or housing will throw all the load on one or two balls.

56. Self-alining ball thrust bearings are so constructed that they will automatically adjust themselves in such a manner that the thrust load at all times is carried by all the balls.

Three constructions are in use for making a ball thrust bearing self-alining. In one, shown in Fig. 27 (*a*), a *leveling*,

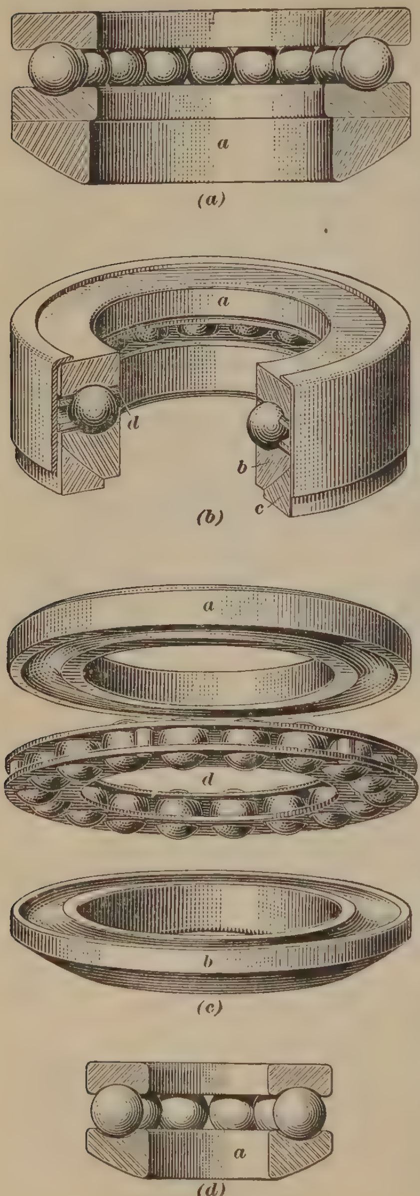


FIG. 27

or *radius, washer a* is placed on one side of a plain ball thrust bearing. One side of the radius washer is flat, and the other side is curved, so as to form part of the surface of a sphere. This curved side of the radius washer is placed against a similarly curved seat; hence, the whole bearing can rock slightly to accommodate itself to any disalinement.

In one form of a Hess-Bright self-alining thrust bearing, shown partly in section in (*b*), one race *a* has a flat outer surface and the other race *b*, a curved outer surface forming part of the surface of a sphere whose center is on the center line of the bearing. A radius washer *c* having a curved inner surface and a flat outer surface fits against the race *b*. The balls are set in a cage *d*, this bearing being of the silent type. A retainer band placed on the outside allows the bearing to be readily handled. In (*c*) the two races *a* and *b* and the ball cage *d*, with its balls, are shown separately. The type of self-alining thrust bearing

shown in (*b*) and (*c*) is placed between flat shoulders, or seats, at the point where it is applied.

In (*d*) is shown in cross-section a full type of self-alining thrust bearing, as used occasionally around the pivot pins of steering knuckles. Here, the one race *a* is curved on its outer surface to fit a spherical seat.

All self-alining thrust bearings are made a very loose fit over the shaft they surround.

57. Ball thrust bearings, when employed in automobile work, are found at one or both sides of the differential in rear axles, on the driving pinion shaft of the rear axle, at the clutch releasing collar, in steering knuckles, and in steering gears; in short, they are found wherever a heavy thrust is to be resisted by a rotating member of a car.

Ball thrust bearings are often employed in conjunction with either radial ball bearings or cylindrical roller bearings and in places where both a radial and a thrust load are to be carried by a rotating member. They are not employed as a general rule in conjunction with tapered roller bearings or cup-and-cone type of ball bearings, as both of these classes can carry thrust loads.

AUTOMOBILE-CHASSIS LUBRICATION

LUBRICATION METHODS AND DEVICES

LUBRICANTS

GENERAL

1. The proper lubrication of an automobile chassis is very important, just as much so as that of the engine. It is a fact that more power is lost by friction in the chassis parts than in the engine. From 15 to 20 per cent. of the power generated by the engine is consumed by friction in the transmission and differential, and as much as 10 per cent. additional may be lost by friction in the wheels. The chassis parts are under a great strain, as, in many cases, the moving parts not only function to drive the car forwards or backwards, but at the same time bear the weight of the car.

Notwithstanding the fact that automobile manufacturers issue elaborate charts showing in detail the proper lubrication to use at different points and the intervals at which such parts should be lubricated, the neglect of car users in this important matter in the past, can be traced to insufficient consideration by car manufacturers of details of design of lubrication facilities. Many of the important points of lubrication have been located in inaccessible places, and the lubrication of the chassis has, as a rule, been such a dirty and disagreeable task

that it was neglected even by those who really were making an effort to keep the car properly lubricated.

Another fact that has contributed largely to the neglect of chassis lubrication is that the temporary lack of lubrication is not immediately apparent in some of the chassis parts; consequently, often no attention is paid to these parts until the neglect is made evident by squeaking or grinding when such parts are moved, by which time, considerable damage may already have been done. In recent years, designers have given special attention to chassis lubrication with the result that considerable improvement has been made. The result of these efforts has been to lessen in some cases the number of places requiring lubrication, to provide bearings with self-contained oiling systems, or to employ lubricating devices that eliminate from the lubrication operation much of the labor and many of the other objectionable features of the old methods. Accessory manufacturers have also come forward with patented devices that can be applied with little trouble and at small expense to new cars or cars already in service, and the automobile user now has little excuse for not giving chassis lubrication the attention it requires.

2. There has been in the past considerable variance of opinion in connection with the lubrication of the automobile chassis, as to whether oil or grease was best suited for this purpose. For some time there has been a gradual gathering of sentiment in favor of oil, but the changes in the design of the chassis necessary to make its use possible, have been largely responsible for its not having been more universally adopted. Much can be said in favor of each lubricant, and each has its staunch adherents, but when all things have been considered, the balance of favor seems to rest with the oil. In favor of oil, it can be said, that if the oil is fed to one particular point in a bearing, it will quickly spread over the entire bearing surface. On the other hand, grease must be forced to all parts of the bearing surface by pressure. Furthermore, as oil will flow by gravity, a continuous supply is given to the bearing as long as there is any oil remaining in the reservoir

from which it is fed; whereas, grease will not remain in contact with the bearing surface unless it is forced in at regular intervals by pressure. Again, oil will sustain as heavy a load as grease and with less friction, and is better adapted to automatic regulation, as it can be fed in proportion to its requirements. There is also less danger of dirt in the oil, as it is practically impossible to separate dirt from grease once they become mixed, while the oil can be filtered.

In favor of grease, it may be mentioned that the grease will make an effective seal around the bearings, and prevent moisture or dirt from entering them. Furthermore, a fresh supply of grease forced into a bearing is very effective in driving out foreign matter which may have worked into the bearings from the ends. The flow of grease does not depend on gravity, and hence the grease will remain on the bearing until worn off, while oil may run out of the bearing when the car is standing still. Devices intended for grease lubrication can be set at any angle or even placed upside down, and this permits of the filler opening being located in a convenient position, even in places otherwise inaccessible.

GREASE

3. Grease is generally made by adding a soap to lubricating oil, thus thickening it. The thickness of grease varies from the consistency of a thick liquid to that of a hard soap. The harder grease contains more soap than the soft grease. The lubricating properties of a grease are not usually available for the reduction of friction in a bearing until the temperature of the bearing has become sufficiently high to melt the soap and thus liberate the oil contained in the grease. The soap adds little, if anything, to the lubricating properties of the grease.

Mineral oil is commonly used in grease, the soap used for thickening it being either a tallow soap or a mineral soap. The tallow soap is made of tallow or other suitable fat which is commonly saponified by the addition of potash, and it is therefore sometimes called a potash-tallow soap. Some of the

vegetable oils, such as olive, rape-seed, and cotton-seed oils, may be saponified by such alkalies as lime, soda, and potash. In mineral greases, a mineral soap such as aluminum soap is used.

4. Since a grease must melt before the lubricant is available, a grease that melts at a temperature sufficiently low to keep the bearing from being damaged must be chosen. Grease melts at temperatures varying from about 75° F. to 150° or 200° F. The melting temperature depends both on the amount of soap in the grease and on the kind of soap. The flash point and the fire point of a grease are usually the same as those of the oil contained in it.

Both grease and oil are frequently used in places where the temperature around the bearing is very high or very low. When the temperature of the surrounding air is high, a grease suitable for use in the bearing must have a melting point only slightly above that of the air, in order that the bearing will not become too hot before the grease melts. Furthermore, if oil, by itself, is employed, neither it nor the oil used in the grease should flash at a temperature less than 100° above the air temperature. If the bearing is exposed to very low temperatures, a grease of such consistency that it will not become hard at the temperature of the air must be used.

Solid materials such as graphite and soapstone are sometimes added to grease to harden it. Graphite also adds valuable lubricating qualities to the grease or oil with which it is mixed, providing the graphite is not used in such quantities as to make a mud and clog the bearing. Graphite smooths the surfaces of the bearing by filling up the hollows and thus reduces both friction and wear.

The greases used in automobile work are made in different consistencies to suit different climatic conditions and service. As a general rule, each brand of grease is made in three consistencies, often known as *hard*, *medium*, and *light grease*, although some makers manufacture five consistencies and give each an identification number. A distinction is usually made between *cup greases*, which are intended to be used in

compression grease cups, and *transmission greases*, which are often called *non-fluid oils.* Transmission greases are very soft and fluid and, as implied by their name, are intended to be used in automobile transmissions and rear-axle housings to furnish a suitable lubricant for their gears and bearings; they are entirely too fluid to be used in grease cups.

The viscosity of many cup greases is greatly affected by the temperature to which they are subjected, the greases becoming more fluid as the temperature rises and less fluid as it becomes lower. With such greases, a hard grade should be employed in summer, a medium grade in the spring and fall of the year, and a light grade in winter, in order that the grease may be fed freely from the grease cups. Some cup greases are affected but little by temperature changes, and then the same grade may be used all the year around.

5. Grease Cups.—The method of chassis lubrication almost universally used in the past, and still employed in some of the lower priced cars, is by grease cups, in which the necessary pressure is obtained by screwing the movable member down by hand. These cups are applied to various points where grease is to be used as the lubricating medium, such as the steering-knuckle pins, spring-shackle bolts, etc. A very simple grease cup extensively used on automobiles is shown in Fig. 1. The cap *a* is unscrewed from the body *b*, and filled with a suitable grease, after which it is again placed on the body *b* and given as many turns as required. The body of the cup is permanently screwed into a hole that runs to the bearing surfaces. The pressure of the cap *a* when screwed down is sufficient to force the grease to the bearing. In case the car has been out of service for some time, the grease cups should be filled up and emptied several times, especially in such places as axle bearings, universal joints, etc., in order to drive out the old grease, and give the bearings a plentiful

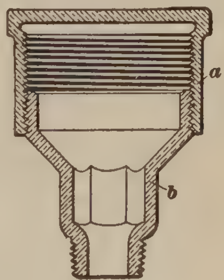


FIG. 1

supply of new grease. After sufficient grease has been forced into the bearings for the time being, the cups should be filled again, so that a turn or two can be given them at regular intervals when the car is in service. After the cups have been filled, all surplus grease should be wiped from the outside of the cups, and the wiping process should be repeated each time the cup is to be screwed down. It is difficult to keep dirt out of the cups, but by observing care in handling them, this objectional feature can be reduced to a minimum.

A great many varieties of grease cups have been and are still in use, but the one shown in Fig. 1 serves to illustrate the general method of lubricating the car by their use. These cups are made of polished, nickel-plated, or rough brass, or of steel. The threads on the shanks are usually standard iron-pipe threads, such as are used on $\frac{1}{8}$-inch or $\frac{1}{4}$-inch pipes. Grease cups requiring larger threads than those used on $\frac{1}{8}$-inch pipe connections are quite rare. The capacity of grease cups used in automobile work ranges from $\frac{1}{8}$ ounce to $\frac{1}{2}$ ounce of grease.

In some places, such as the spring-shackle bolts, the thread for the grease cup is cut on the extended end of the bolt, the outer member of the cup being all that is necessary in such cases.

6. Special Grease Devices.—The method of greasing a car by the ordinary hand cups, in addition to being a hard, disagreeable task, is unsatisfactory in other ways. It is difficult to prevent dirt from working into the bearings, and if pressure sufficient to force the old grease out of the bearing is exerted on the cap, part of the grease will be squeezed out between the cap and the body of the cup. The undesirable features of using grease may be largely eliminated, without detracting from its lubricating qualities, by substituting for the common grease cups any one of the numerous systems now on the market for lubricating chassis parts.

7. The **Searing grease cup,** manufactured by the Lewis Searing Company, Detroit, Mich., and illustrated in Fig. 2, is a considerable improvement over the ordinary method of

handling grease in grease cups. This cup is used as regular equipment in some cars, and can easily be applied to others in place of the cups supplied with the car. Adapters are provided for places where the old cups were screwed directly on to the ends of the bolts. The grease used in the Searing cup is packed in small paper cartridges and this insures clean grease entering the bearings, and the disagreeable conditions which accompany the use of the common type of cups are eliminated.

As shown in Fig. 2, the Searing device consists of a cup *a* with bayonet slots *b*, and a cover *c*, having a piston *d* carried on the threaded stem *e* of the handle *f*. In addition to the piston *d*, the stem *e* is provided with an extractor *g* which

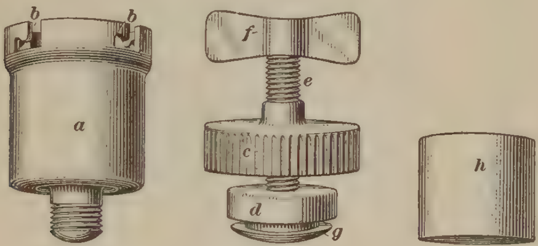


FIG. 2

automatically removes the empty cartridge from the cup when the handle *f* is unscrewed. The grease cartridge is shown at *h*. To use the cup, the grease cartridge is inserted, the cover is placed over the cup and locked in place by pressing down firmly on it, at the same time giving it a slight twist to the right. The handle *f* is then screwed in to force the grease into the bearing. The fingers, only, should be used to turn the handle, as sufficient pressure is exerted on the grease to force it to the bearing unless there is a stoppage of the grease line at some point. In case the grease cannot be forced into the bearing by the fingers, the part being lubricated should be removed and the grease passage cleaned out.

8. Systems embodying this high pressure feature, but using grease guns, are included in the equipment of a large number of passenger cars and trucks. These systems may

also be applied to cars in service with few alterations and at small expense, and they provide a much more convenient and effective method of applying the lubricating grease to the chassis than by the use of grease cups. A system of this kind known as the **Dot lubrication system** and manufactured by the Carr Fastener Company, Boston, Mass., is shown in Fig. 3. It consists essentially of a high-pressure grease gun, as shown in (*a*), and suitable nipples, or connectors, shown in (*b*) and (*c*). The gun is of very durable construction, being built to withstand a pressure in excess of 3,000 pounds, which pressure it is claimed by the makers, may be generated with this gun. The gun is made up of the barrel *a*, which is knurled on the outside so as not to slip in the hand; the threaded stem *b* carrying a plunger at its inner end, and by which the grease is forced from the barrel into the bearing; and the nozzle *c* with its opening *d* so shaped as to conform to the shape of the body of the nipple over which it fits.

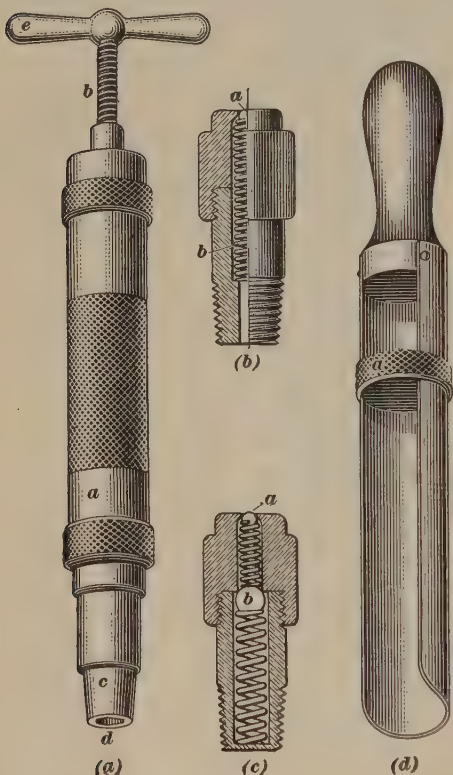


FIG. 3

The chief feature of this gun is the automatic valve carried in the nozzle end. To apply the gun, the nozzle is slipped on to the nipple and given a quarter turn to the right. This quarter turn first securely clamps the gun to the nipple, and

then automatically opens the valve in the nozzle. After the bearing has been lubricated by turning the handle *e* one or more turns, as required, the gun is detached by a quarter turn to the left, which first closes the valve and then unclamps the nozzle. Some of the working advantages of the automatic valve are as follows: The gun may be used with oil as well as grease, and the gun can be left in any position without danger of leakage of oil or melted grease. The pressure in the gun can be previously raised by screwing the handle in before applying the gun to the nipple, which will give automatic lubrication to the bearing as soon as the attachment is completed. This feature makes possible the handling of the gun with one hand, which is an advantage for certain remote bearings. The closing of the valve at the end of each operation eliminates the necessity of relieving the pressure in the gun before detaching it from the nipple, and thus pressure is maintained in the gun which can be utilized to lubricate the next bearing without turning the handle of the screw.

The nipples of the Dot system, one of which is shown partly cut away in Fig. 3 (*b*), are made in all the various forms necessary to adapt the system to any lubricating point on the chassis. The nipple illustrated is a straight nipple, but others are furnished in various angles and with different threads. To apply them to a car already equipped with grease cups, it is necessary only to screw out the old cups, and substitute nipples of the same size thread and of shapes best adapted to their location. By choosing nipples of the form most convenient for the parts to be lubricated, it is possible to equip the car so that the lubricating operation will become a comparatively simple matter.

As shown in Fig. 3 (*b*), the nipple has a check valve *a* which is held firmly to its seat by the spring *b*. This valve prevents dirt or moisture from entering the nipple. A special form of nipple for use at the water pump bearings is shown in section in (*c*). In addition to the usual small check valve *a* there is a larger valve *b* held to its seat by a spring. The check valve *b* prevents any leakage of water from the pump through the nipple.

Dust-proof caps are a part of the complete equipment, and the car user should see that all nipples, when not in use, are kept covered by these caps. In case any are lost, the nipple should be wiped carefully before the nozzle is applied, and new caps should be installed as soon as possible.

9. One drawback to the use of grease guns in lubricating the automobile chassis has been the difficulty experienced in filling the gun properly, because of the formation of air pockets underneath the grease. In the Dot system, this drawback has been overcome by a special filler which is supplied as a part of the regular equipment. This filler, shown in Fig. 3 (*d*), holds enough grease to fill the gun, which amount is sufficient to lubricate all the bearings on any car. The filler is plunged into the grease in the container, given a complete turn, and withdrawn. It is then placed in the open barrel of the grease gun, and, with one hand holding the slide *a* flush with the top of the gun, the filler is withdrawn, the barrel of the gun thus being filled uniformly with grease.

Adapters are provided for points where the body of the old grease cups is integral with a bolt or pin. These adapters are threaded at one end to fit the thread on the end of the pin, and have an opening in the other end into which the lubricating nipple may be screwed.

A wrench having an opening shaped to fit the body of the nipple is furnished with the equipment for the purpose of screwing the nipple into the opening in the bearing.

10. Another lubricating system operating on practically the same principle as the one just described, and which is supplied as regular equipment on a great many automobiles and trucks, is the **Alemite system** shown in Fig. 4. This system is manufactured by the Bassick Mfg. Company, Chicago, Ill., and, as shown in the illustration, consists of a high-pressure grease gun and suitable nipples. The gun, or compressor, consists of a cylinder *a* which is knurled so that it can be firmly held in the hand. One end of this cylinder has attached to it the flexible steel tube *b*, and the other end carries the cover through which extends the screw *h*. This screw carries a

plunger on the end within the cylinder, and the flexible tube has at its outer end a bayonet coupling *c*. This coupling is similar to that used in the lamp sockets of the electric lighting equipment of the car, and permits of making a tight joint between the coupling and the nipple. As shown at *d*, the nipple, or connector, has a ball check valve which is held to its seat by a spring inside the body of the nipple. Two steel projectors extend from diametrically opposite sides of the nipple. The gun is applied by placing the coupling over the nipple with the steel projections opposite the slots in the coupling; a slight pressure inward on the coupling and a slight turn to the right serves to make an absolutely tight joint.

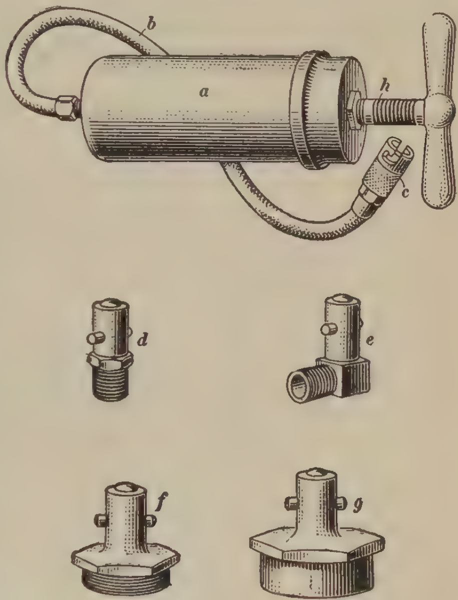


FIG. 4

This system can also be applied to cars already in service, and the makers have provided for any requirement that might arise in making the change from the regular grease cups to the perfected Alemite system. A 90-degree elbow nipple is shown at *e*, Fig. 4, but other forms may be obtained to conform to practically any requirements of chassis lubrication. Double-valve connectors are provided for the water-pump bearings to prevent leakage of melted grease from the nipple when the water has become hot. Reducers are also provided so that a regular fitting can be applied to a larger-size opening. Thus, in the case of the steering worm housing, a $\frac{3}{8}$-inch plug is generally provided. By replacing this plug by a $\frac{3}{8}$-inch

reducer, a regular $\frac{1}{8}$-inch Alemite fitting can be employed to pack the housing with grease. In cases where the grease cup body is integral with a bolt, a cap and nipple complete in one are furnished. Fittings of this kind are shown in *f* and *g*, Fig. 4; that shown at *f* is used where the thread is on the inside of the bolt opening, and the one at *g* where the thread is on the outside.

11. The Alemite system was open to the same objection as other grease gun systems in that difficulty was experienced in filling the barrel of the gun with grease, due to the presence of air in the barrel. The makers have overcome this obstacle by placing on the market, under their name, a special lubricant in a container having an easy filling arrangement. The top of the can is a free-fitting disk with a hole in the center slightly smaller than the opening in the barrel of the grease gun. The cover is first removed from the gun, and the barrel is placed with its open end directly over the hole in the top of the grease container. A slight pressure is then exerted on the top of the barrel by the hands, and grease is forced through the opening in the disk, and fills the gun barrel, enough space being left around the sides to permit the escape of air, and thus insure a complete filling of the gun.

Dust caps are furnished with this system, and these should always be kept in place. Any nipple not being protected from dirt in this way should be wiped carefully before applying the gun to prevent the dirt from being forced past the check valve and into the bearing.

In using the Alemite grease gun, a turn or two should be given to the handle to unscrew the stem *h* before uncoupling the hose from the nipple, so as to relieve the pressure in the gun. Otherwise, grease will be forced out of the end of the hose when the connection is broken.

OIL

12. In order to obtain an efficient and economical application of oil to the lubrication system of the automobile chassis, the system must be so designed that clean oil, only,

will enter the bearings; that sufficient oil will be supplied to flush the bearing properly but not in such quantities that it will run out of the bearing and be wasted; and that each point of lubrication shall be independent of every other point, so that a failure of the oil supply at one bearing will not cut off the oil from other bearings. Some of the most common methods of supplying the lubricating oil to the bearings, as employed in modern cars, are by the use of wicking, by oil cups of various types, or by complete oiling systems wherein the oil supply is controlled from a single point within easy reach of the driver.

13. Wick Oiling.—Wick oiling of certain plain bearings of the chassis has been used successfully in a few cases by automobile and truck manufacturers. The spring bolts of the Franklin car for a number of years have been made hollow, and the openings filled with felt wicking. The oil is automatically fed to the bearings by capillary attraction through the wicking. The main drawback to this method of oiling is that it becomes inoperative if, in cold weather, an oil is used that congeals at low temperatures. To overcome this, it is a good plan to use a mixture of about 50 per cent. cylinder oil and 50 per cent. kerosene oil in the wick-equipped bearings during extremely cold weather. The oil drained from the engine reservoir may be used for this purpose; the wicking will filter out the dirt and other foreign matter. In the Franklin car, the clutch and brake controls are also equipped with wick oiling devices. Other manufacturers have used this system satisfactorily in the lubrication of the drag links of the steering mechanism.

14. Oil Cups.—Oil cups for automobile chassis lubrication are constructed so that the oil supply to the bearing is restricted, as otherwise, the bearing will receive an excess of oil for a little while, but the supply in the cup will be speedily exhausted. This restriction of the oil flow is accomplished in different ways in the many oil cups now on the market for automobile use. In some cups, wicking is employed, so that oil is fed to the bearings in small amounts; in another type, the supply is varied by hand; while in still other cases, the cup

is so constructed that the oil is supplied to the bearings by the movement of the car when it is running. These cups can be used in cars already in service in place of plain oil or grease cups with which the cars were originally equipped.

In a few cases, the plain oil cup with sliding or spring-retained cover, is still in use in connection with certain bearings on the chassis, but such cups are open to the serious objection that they require daily attention, and collect considerable dirt which finds its way into the bearing. All such cups should be wiped thoroughly before opening them for the introduction of new oil.

15. An example of a cup using wicking is shown in Fig. 5, which illustrates the **Empress cup** manufactured by the

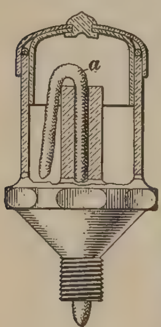


FIG. 5

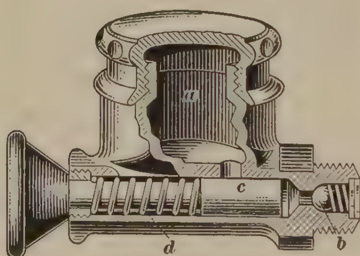


FIG. 6

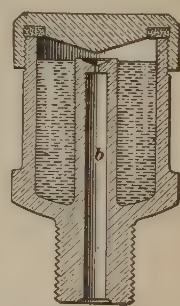


FIG. 7

Bowen Products Company. After this cup has been filled, the oil is fed to the bearings at the rate of a few drops a day by the wick *a*.

The cup shown in Fig. 6 is manufactured under the trade name of **oil-kipp** by the Madison-Kipp Corporation, and is of the hand operated type. The cup consists of a reservoir *a* which will hold enough oil for several injections, a ball-check valve *b*, plunger *c*, and closing spring *d*. The oil is forced past the check-valve into the bearing by pulling out and releasing the plunger *c*, considerable pressure being exerted on the oil by the spring *d*.

A very simple oil cup in which the oil is caused to flow to the bearing by the movement of the car when running, is shown

in Fig. 7. This cup is manufactured by the Bloom Flusher Company. When the cup is first filled to the top, the oil runs to the bearing through the opening *a* until the oil level is even with the top of the standpipe *b*. When the car is running, its motion causes the oil to splash into the conical cup in the top of the standpipe, whence it passes through the opening *a* to the bearing. As the quantity of the oil in the cup decreases, the splash is increased, so that nearly the entire contents of the cup will pass to the bearing. No oil will be fed to the bearings when the car is not running.

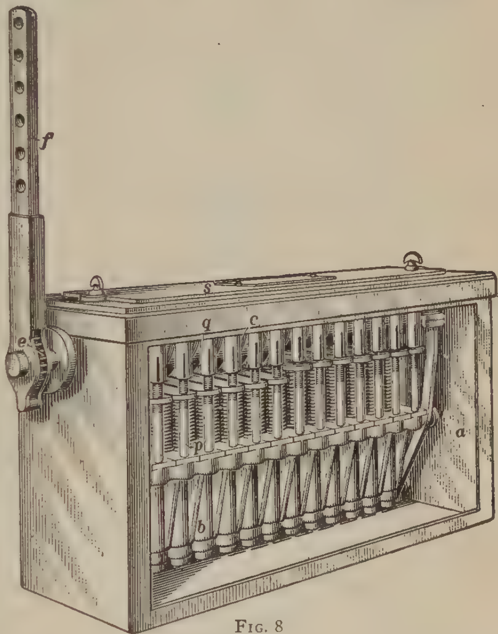


Fig. 8

16. Oiling Systems.—Automobile chassis oiling systems are now being built wherein the lubricating oil is contained in a single reservoir, and is fed to the lubrication points of the chassis under pressure by means of individual distributing lines. These lubricators can be applied to any chassis, either as regular equipment, or to cars already in service, special fittings being provided to cover the requirements of individual cars. A very successful system of this kind is the **Romon automatic chassis lubricator,** manufactured by Roberts & Monroe, Inc., New York, N. Y., and illustrated in Figs. 8 and 9. Fig. 8 shows the general construction of the lubricator, the near side of the enclosing member being removed to disclose the interior. The lubricator consists of

a reservoir *a* of suitable size for the chassis on which it is mounted, and a series of plunger pumps *b* which distribute the oil under high pressure through the system. The plunger pumps *b* are depressed by cams *c* and are returned to their original position by means of the return springs. The cams *c* which drive the pumps are cylindrical shafts set off center, and are rotated by a ratchet-and-pawl arrangement *e* operated by a reciprocating or to-and-fro motion of a lever *f* on the outside of the reservoir *a*.

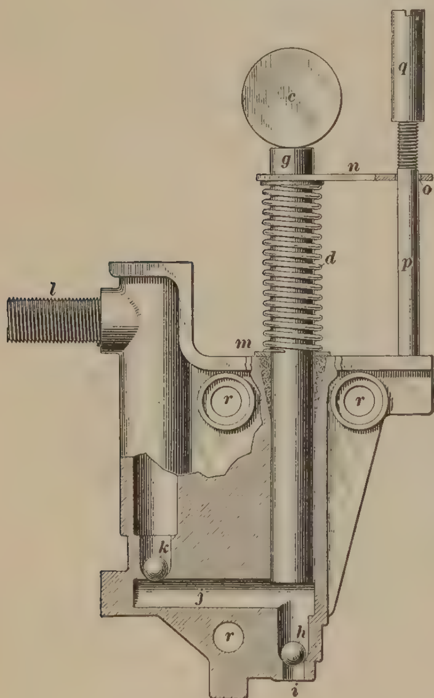


FIG. 9

17. The construction and operation of one of the plunger pumps is shown in the part sectional view Fig. 9. The same reference letters are used in this illustration as in Fig. 8 on parts appearing in both figures. The rocking of the lever *f*, Fig. 8, turns the cam-shaft *c* through the ratchet-and-pawl mechanism, and depresses the pump plunger *g*. The depression of this plunger forces the oil in the pump chamber below the plunger against the ball check-valve *h*, closing the intake passage *i*, and drives the oil through the passage *j* and past the ball check-valve *k* to the oil line leading to the chassis lubrication point. The connection from the pump to the oil line is shown at *l*. A further rotation of the cam moves it out of contact with the top of the plunger *g*, and the plunger is raised by means of the return spring *d*. This upward motion of the

pump plunger causes the ball check-valve *h* to rise, allowing a new supply of oil to enter the chamber below the plunger, and, at the same time, holding the ball check-valve *k* to its seat, thus preventing the return of the oil already forced to the lubrication line. This system of locating ball check-valves insures an even flow and supply of oil to all bearings, regardless of their distance from the main reservoir. The high pressure exerted by the pump plunger *g* insures against the distributing lines being clogged up, and leakage around the plunger is prevented by packing *m* which is placed in the tapered opening at the top of the cylinder, and is held in place by a plate underneath the spring *d*.

The extension *n* is fastened to and moves with the plunger, the opening *o* allowing it to slide up and down on the upright stem *p*. Consequently, the upward motion of the plunger is

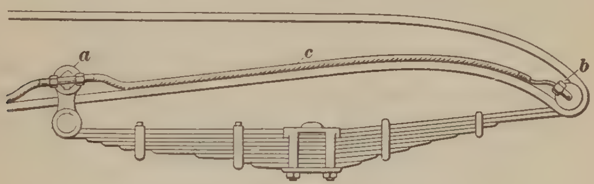


FIG. 10

limited by the position of the cylindrical stop *q*, which can be screwed up or down on the threaded end of the stem *p*. This makes possible a variation in the oil output from the different pumps, which is desirable, as some bearings require a more copious lubrication than others.

Long bolts pass through the holes *r* and bind the pumps and end bearing sections into one solid unit, as shown in Fig. 8.

A number of special fittings are provided to take care of road vibrations, and to make all oil connections tight yet flexible. An individual line leads from the pump connection at the oil reservoir to the bearing connection, there being thus as many oil connections at the main reservoir and as many plunger pumps as there are oil lines. An advantage of these individual lines is that the stoppage of any bearing or oil line will not affect the operation of any other part. An example

of the method employed in the **Romon system** for distributing the oil to the different bearings, is given in Fig. 10, which shows the front and rear spring-shackle joints. The oil fittings are shown at *a* and *b*, and the flexible tube leading from the oil reservoir at *c*.

The oil reservoir can be located at any convenient point, being usually placed underneath the floor boards of the front compartment, the hand lever thus being within easy reach of the driver. The handle is operated for 5 or 6 seconds once a week, or oftener if the car is driven very much, thus flooding each bearing with oil. It is advisable once or twice a year to fill the reservoir with kerosene, and force it through the system, thus cleaning all bearings of any encrustment, dirt, or grit that may have collected there, after which they should be flushed with clean lubricating oil.

The main reservoir is filled through an opening in the top, which is normally kept closed by the cover *s*, Fig. 8. This cover should be removed at frequent intervals and the quantity of oil in the reservoir noted. After a car has been in use for some time, and the bearings are lubricated at regular intervals, the driver will soon learn the length of time required before refilling is necessary.

LUBRICATION OF CHASSIS DETAILS

18. Transmission and Differential.—The use of grease in transmissions and rear axles is not so common now as formerly, many automobile manufacturers recommending the use of a heavy, steam-engine cylinder oil instead. Ordinary, cheap, steam-engine cylinder oil is of little value as a lubricant for transmissions and rear axles; best results are usually obtained from a cylinder oil suitable for superheated steam and having a fire-test of about 600° F.

Some transmission greases are of a fibrous nature and cling to the gears with great tenacity; better results are usually obtained from such greases than from greases that are so fluid that they will drip at once from the gears. Greases that are so heavy that the gears simply cut a path through them are of

no value in transmissions or differentials; by mixing them with gas-engine cylinder oil, however, their consistency can often be reduced so that they will give satisfactory service. A transmission grease that is too light to cling to the gear-teeth can be thickened by mixing it very thoroughly with a sufficient quantity of heavy cup grease. As a general rule, however, it will be more satisfactory to use a lubricant of the right consistency than to attempt to obtain it by mixing as just described.

Care should be taken to use in the transmission the kind of lubricant which the designer intended. In some transmissions, as in the Hupmobile, for instance, oil leads and grooves are provided for the distribution of the oil to the various bearings, and grease or too-heavy oil will clog the leads and cause injury to the bearings. During the winter months, the same lubricant should be placed in the transmission case as is used in the engine. In the summer, an oil of greater body, such as the steam-engine oil known as 600-W, is recommended.

The use of a heavy grease in the automobile transmission and differential has a material effect on the power of the engine, which militates against its use even though it may adhere to the gears and be otherwise satisfactory as a lubricant. The difference in frictional resistance between oils and heavy greases has been aptly compared to the resistance that is offered by ice cream when it is first put into the freezer, and the same ice cream when it has been frozen. Oil cannot be used in all transmissions and differentials because of leakage. If there is a leak when the lubricant is at the proper level, the use of the lightest-bodied semi-fluid grease that will stay in the housing is recommended.

19. When the car is new, both the transmission and the differential housings should be drained, washed out with kerosene, and refilled with new lubricant, after the first 500 miles. Thereafter, the car should be inspected at least every 1,000 miles, and oftener if convenient, to determine the amount of oil in the housings. Most cars are provided with oil-level plugs in both the transmission and the differential housing.

These plugs should be removed, and lubricant introduced into the housings until it runs out of the openings. In some cases, no such openings are provided, and it is then necessary to remove the inspection cover or plug. The level of the lubricant should be about a half inch below the bottom of the main bearing in the transmission and about an inch below the bottom of the rear-axle shaft bearings in the differential. The use of an excessive amount of lubricant in either of these places should be avoided, as all lubricants expand when heated, and this expansion in a confined area creates a pressure that forces the lubricant through the felt retaining washers. In the rear axle, this will result in greasy brake drums, and unsightly wheels.

All transmission and differential housings should be drained, cleaned thoroughly, and refilled to the proper level every 2,500 miles; in a car driven the year around under the usual conditions, this amounts to about once every 4 months.

20. Steering Gear.—Outside of accidents due to failure of the automobile brakes in an emergency, probably more serious accidents have resulted from defective steering gear than from any other single cause. In order that the steering gear may perform its important function properly, it must be kept in adjustment, and lubricated at regular intervals. Points requiring lubrication are the top of the steering column, the gear housing, the drag-link ball and socket joints, the steering knuckles, and the pins at each end of the tie, or distance, rod.

One or more oil holes are generally provided in the hub of the steering wheel, and a few drops of cylinder oil should be applied to this point about every 500 miles. In the Ford car, the reduction gears are located at the top of the steering post, just below the hub of the steering wheel. About every 2,000 miles, these gears should be cleaned and a fresh supply of very light grease should be given them. In order to get at these gears, it is first necessary to unscrew the nut on top of the steering column, and drive the wheel off the shaft with a block of wood and a hammer. The setscrew in the gear cover can then be unscrewed, after which the cap can be lifted off.

The grease cup on the steering-gear housing should be turned a couple of times, or a little lubricant should be forced into the housing by the high-pressure gun, every 100 miles. About once in every 2,500 miles, an entirely new supply of grease should be given this housing. It is a good plan in renewing the grease to open the gear housing at a second point, either by a suitable plug, or by unscrewing the adjusting nut at the top, so that the entering fresh grease will force the old grease out of the housing. Hard grease should never be used on the steering gears. A very good lubricant is formed for this purpose by adding a little flake graphite to the steam-engine cylinder oil supplied for the transmission. The advice of the maker should be followed in purchasing steering-gear lubricant for any particular car.

The drag-link joints should be packed with a light grease once every 500 miles. Unless a grease cup or a grease-gun fitting is provided at these joints, it is advisable to enclose them in leather boots which can be kept packed with grease, and thus increase the efficiency of the joint. If oil cups are provided, a few drops of oil applied every day or two will keep the joints well lubricated and in good working condition.

The steering-knuckle bearings should be attended to every few days by forcing light grease into them, or by replenishing the supply of oil every few hundred miles; enough fresh lubricant should be forced into these bearings to drive out all the old worn-out grease.

The grease cups, or oil cups, at each end of the tie-rod should be attended to at the same time as the steering-knuckle bolts, the same kind of lubricant being used in both places.

21. Wheels.—About every 2,000 to 3,000 miles, or at least once every 6 months, if the car is driven continuously throughout the year, all of the wheels should be removed, and the bearings together with the wheel hubs washed with kerosene oil. Where convenient, the bearings should be entirely removed, placed in a receptacle containing the kerosene oil, and washed thoroughly with a stiff brush. The old grease should be entirely removed from the wheel hubs, and the

interior cleaned thoroughly. The hubs should then be packed with a light-bodied grease, the bearings filled up with the grease, the wheel replaced, and the bearings properly adjusted. In the cup-and-cone type of bearing, the bearing cup need not necessarily be removed. The ball retainer can be slipped out of place, after which the balls can be removed, and the cup and the interior of the hub can be cleaned out. In reassembling the balls in a bearing of this type, if the ball retainer is lost, the cup should first be filled with grease, and the balls stuck into it. The grease will hold the balls in place while the wheel is being replaced on the spindle. In remounting the wheel, care must be taken to see that the felt washer is in its place. If it is not in good condition, it should be replaced by a new one. In most cases this washer is partly encased in a metal housing and sometimes, as in the case of the Ford car, must be pressed into the inner end of the wheel hub, after the inner bearing has been placed in position. In connection with wooden front wheels, it is advisable to fill the hub caps with grease, which will be forced into the outer bearing when the cap is screwed into place. After every 500 miles, the cap should be removed and repacked with grease.

22. In rear axles of the semifloating or the three-quarter floating type, it is necessary to remove the wheels in order to make the bearings accessible. Except in a few cases, where the axle is confined at its inner end by the differential side gear, a large bearing-adjusting nut must be unscrewed to free the bearings, which may then be removed and cleaned. In the full-floating axle, the wheels are first freed from the axle, either by unscrewing the hub cap and withdrawing the axle, or by unbolting the wheel driving flange. The clamp screw, if one is employed, is then loosened, and the wheel bearing-adjusting nut is unscrewed, after which the wheel may be removed, using a wheel puller if necessary. In pulling off the wheels, the outer bearings will come off with them. The inner bearings should then be removed, washed out thoroughly with kerosene, packed with clean, thin grease, and replaced. After the same has been done with the outer bearings, these bearings and the wheels

are replaced, and the bearings nuts set up properly. Fresh grease can be forced into the bearings of full-floating axles at frequent intervals by removing the hub caps, filling them with grease, and screwing them into place again.

One or more felt washers are used at the outer ends of the axle housing to prevent oil or grease from the differential from working out into the brake drums. These washers must be in good condition and replaced in exactly the same position from which they were removed, if oil leakage is to be prevented.

When rear axle outer bearings are provided with grease cups or fittings for a grease gun, fresh grease should be forced into these bearings every few hundred miles.

Some wire wheels have lubrication openings in the middle of the hubs. These small openings, which lead to the wheel bearings, are exposed when the wheel is removed and the pipe plug unscrewed. Grease can be forced through these openings to fill up the space in the wheel hubs, after which the pipe plug should be replaced. A little grease should be placed on the hub threads, hub-cap threads, and wheel hub shell before the wheel is replaced. Where hub caps are provided with a latch for locking them in place, a few drops of oil should be put on the latch to prevent its sticking. There is no advantage of packing the hub cap with grease, however, as the grease will not be forced into the bearings as on wooden wheels.

23. Clutch.—A cone clutch which is not intended to run in oil does not require any lubrication other than in the operating mechanism and thrust bearing, and should be kept free from oil. In case the leather surface becomes hard and dry, as evidenced by a fierce engagement with the flywheel, it should be flushed with gasoline, and then given an application of neat's-foot, or castor oil. In case the leather has become oily or greasy, indicated by a slipping clutch, the surface should be washed thoroughly with gasoline to remove the oily matter, and when the gasoline has entirely evaporated, a dressing of neat's-foot oil should be applied to the leather.

Where a cone clutch runs in oil, as in the Maxwell car, fresh oil should be added at frequent intervals to keep the oil level up to the desired point. In the Maxwell car, the clutch housing should contain about $1\frac{1}{2}$ pints of cylinder oil to obtain the best results. This oil is added as required through a hole in the top of the left arm of the flywheel housing. It is advisable to drain out the old oil at the end of every 2,000 miles, and refill with fresh oil, as the old oil will become gummy and cause the clutch to slip. The removal of the large pipe plug from the bottom of the clutch housing will permit the old oil to run out. The clutch and interior of the housing should be flushed with kerosene, which is allowed to drain out before the renewal of the lubricating oil.

24. Dry-plate or dry-disk clutches require very little lubrication, if any, other than that necessary for the proper action of the clutch spider, the throw-out collar, and the thrust bearing. In the Borg-and-Beck dry-plate clutch, which is now being used as regular equipment in a large number of cars, the makers recommend that in case the clutch does not work smoothly, one of the adjusting screws be removed, and about three spoonfuls of cylinder oil be squirted into the clutch to moisten the friction rings. An excess of oil must be avoided, however, as the clutch will slip until the oil is burned out. Every few thousand miles, the clutch should be cleaned out by removing an adjusting screw and pouring about a half pint of kerosene into it. The engine should then be run for about a quarter of an hour, after which the front end of the car should be raised up higher than the rear, and kept in this position over night, so as to allow all of this oil to drain out.

When an opening is provided in the bottom of the housing enclosing a dry-disk clutch, to serve as a continuous drain for any oil or grease that may collect there, this opening should be kept free at all times. A stoppage of the opening will allow oil to work into the clutch, and impair its action.

The clutch used in the Hudson and the Essex cars is an example of a multiple-disk clutch running in oil. The clutch operates in a half pint of kerosene and lubricating oil, mixed

in equal proportions. At least once a season, the old oil should be drained out, and the clutch cleaned thoroughly with kerosene. Access to the clutch is gained by removing a plug in the flywheel. This plug is reached through the observation hole in the flywheel housing, and can be screwed out by a special wrench provided for this purpose. After the clutch is flushed, the kerosene is drained out, and replaced by a half pint of clutch oil, consisting of 50 per cent. cylinder oil and 50 per cent. kerosene.

25. Faulty lubrication of the clutch-thrust bearing has in the past been the source of much trouble, clashing of transmission gears and hard shifting having often been traced to this point. The present tendency of design toward automatic lubrication of the clutch bearing is, therefore, welcomed by automobile users. In many cases this bearing runs only when the clutch is disengaged, and thus it requires less lubrication than the types of clutch where the bearing runs continuously. It can, therefore, be packed with enough grease to last for several thousand miles. When the bearing runs continuously, however, frequent lubrication is required, and means of lubricating the bearing readily are provided.

The self-oiling feature of the clutch collar of the Chevrolet, F B model, car is obtained by means of a special clutch-collar insert. This insert is of wood impregnated with a filler, the function of which is to lubricate the clutch collar. The only attention required by this device is the renewal of the wooden insert when it has become too thin for service.

In the Franklin car, an oil reservoir is provided in the part through which the pressure for releasing the multiple-disk clutch is applied, and the oil is carried by a wick from this reservoir to the bearing surfaces. In summer this reservoir should be filled with cylinder oil once a month, and in winter, with a mixture of 50 per cent. cylinder oil and 50 per cent. kerosene.

Where oil or grease cups or special fittings are provided for the lubrication of any part of the clutch-operating mechanism, these should receive regular attention. In some cases, a slight injection of grease each day is advocated.

26. Universal Joint.—A universal joint is subjected to considerable strain while the car is running, due to the variation in alinement between the shafts which it connects, and it is efficient only when it is kept well lubricated. In all modern automobiles, universal joints of the metal type are enclosed in a housing, which serves to protect the joint from sand and dirt from the road bed, and also helps to keep the lubricant in contact with the working parts of the joint. To keep the universal joint in good working order, it is necessary to lubricate it at regular intervals. Nothing is gained by packing the housing with all the lubricant it will hold at one time, and then expecting the joint to run indefinitely without replenishing the supply. The centrifugal force set up by the constant rapid rotation of the joint tends to throw the lubricant away from the working members and leave them dry, although an examination may show a large quantity of lubricant remaining in the housing, and that the joint is to all appearances well lubricated. Better results are obtained by placing enough lubricant in the universal joint at a time to about half fill it, and then renew it at frequent intervals, say every 500 or 1,000 miles, according to the design of the joint.

27. It is a good plan to clean out the joint at least once a year, and after drenching it with a good quality of steam-engine oil, to pack it about one-half full of soft grease. A small amount of steam-engine oil can then be injected at intervals through the grease hole after removing the plug. When the car is running, this oil will work into the parts of the joint not already covered with grease. A special nipple fitting for a high-pressure grease gun can be screwed into the grease hole in place of the plug.

Whenever Spicer universal joints are disassembled, care must be observed in reassembling them to see that the bolt holes in the flange and those in the inside casing are matched up in such a way as to bring the grease hole opposite an opening in the joint, and not opposite one of the lugs, which would prevent the introduction of the lubricant through the hole.

Fabric universal joints, which are manufactured under the

trade names of *Flexite*, *Thermoid-Hardy*, etc., require no lubrication.

28. Electrical Equipment.—The number of working parts of the modern magneto have been reduced to a minimum, and the interior is protected against the entrance of water or dirt. Consequently, aside from the care of the contact points of the circuit breaker, about the only attention required by the magneto is lubrication, which should be provided regularly and sparingly. An oil opening is usually provided at each end of the armature shaft, and a few drops of oil should be placed in these openings at the end of each 1,000 miles. This is sufficient lubrication, and nothing is gained, but considerable harm may result, if this amount is exceeded. If oil works its way into the distributor, serious trouble may result, and oily interrupter points cause irregular operation of the engine. While cylinder oil is generally considered satisfactory for magneto lubrication, this oil has a tendency to become gummy, and it is better to use a lighter grade of oil, such as sewing-machine oil, or that sold under the trade name of *3 in 1*.

The only lubrication required by the interrupter mechanism is a trace of vaseline on the cam surface. The finger should be rubbed over the cam after the vaseline has been applied to remove any surplus.

29. In the circuit-breaking mechanism of the modern timer-distributor, the only lubrication required is a very slight trace of vaseline on the fiber block or cam every 1,000 miles. As the distributor shaft usually runs in ball bearings, provisions are made for lubricating these bearings. In the Delco system, lubrication of the upper bearing is taken care of by an oiler located near the top of the distributor housing. Three or four drops of cylinder oil should be placed in this oiler every 500 miles. The lower ball bearing of the distributor shaft and the advance ring of the main spark-control mechanism, receive their lubrication from the light cup grease carried in the lower part of the distributor housing. The cover plate near the spark-advance lever on the forward side of the housing

should be removed at intervals, and sufficient light grease introduced through the opening to fill the housing to a level just above the advance ring.

The automatic spark-advance mechanism of the North-East ignition apparatus is carried in a compartment containing sufficient grease to serve for several years without renewal. There should never be more than 3 cubic inches of grease in this case at one time, and nothing but a very light cup grease should be used. The horizontal shaft of the ignition apparatus besides being lubricated by grease from the automatic-spark advance, is also supplied with grease from a cup. This grease cup should receive attention every few thousand miles.

The distributor bearing of the Remy ignition device is lubricated by grease from a grease cup located just beneath the distributor housing. Two or three turns should be given this cup every 1,000 miles.

In the Wagner system, the pivot upon which the interrupter lever moves is lubricated by a small wick contained in the hollow spindle beneath the spring clip. Three drops of cylinder oil on this wick will give sufficient lubrication for an entire season. A grease cup is located in the side of the upright housing in which the distributor shaft runs, and this cup should be filled with a good grade of light cup grease. A half turn should be given the cup every 500 miles.

When the distributor cap of the Atwater-Kent system is removed, an oil hole will be found near the center of the interrupter head. A drop or two of cylinder oil should be put into this hole every 500 miles to lubricate the vertical shaft.

The Connecticut timer-distributor has a grease cup located immediately under the interrupter head, and the instructions of the manufacturers are that nothing but pure vaseline should ever be used in this cup. The cup should be refilled and given a turn every month. If the car is driven more than 1,000 miles in a month, this must be done every 1,000 miles.

The Ford timer should be lubricated at least every 200 miles. In the absence of a speedometer to show the mileage, a safe plan is to oil the timer daily. The Ford Motor Company

recommends that 25 per cent. of kerosene be mixed with the regular lubricating oil in cold weather, to prevent the oil from congealing. Difficult starting and irregular running of the engine in cold weather is very often caused by the timer rotor failing to make proper contact with the stationary segments, because of thick lubrication in the timer casing.

30. Electric generators and starters, or motor-generators must be lubricated in order to keep their bearings in good working order, but the lubrication requirements differ according to the design of the machine, and no general instructions can be given that will be applicable in all cases. Accordingly, the recommendations of a few of the makers for the lubrication of some of the most common systems will be given briefly.

In the Leece-Neville system, as used in different models of the Haynes car, the rear generator bearing is provided with an oiler, into which a few drops of cylinder oil should be put every 500 miles. The front bearing compartment should be packed with a light grease every 1,000 miles.

The North-East dynamotor, as used in the Dodge Brothers car, has the ball bearing at each end of the armature packed in a special grease. This will usually provide adequate lubrication for the machine under normal conditions of service. A further means of lubrication is provided, however, by the oil splash from the engine timer-gear case at the front end, while a small oil hole is provided at the rear or commutator end. A few drops of oil should be placed in this opening every 2,000 to 3,000 miles. In North-East systems employing a separate generator and a starting motor, both machines are provided with oil openings at either end of the armature. Three or four drops of oil should be put into each oiler every 1,000 miles.

In the Westinghouse electrical system, oilers are provided at the top of the bearings on both the generator and motor, and these should receive three or four drops of the best grade of machine oil once a month. Where there are oil cups suspended below the bearings, the old oil should be cleaned out, and the cups refilled with vaseline, or some other good grade of light lubricant.

In the Remy equipment, the generator armature shaft rotates in large sleeve bearings, the front bearing being so arranged as to receive constant lubrication from the oil in the engine timer-gear case. The rear bearing is provided with a large oil well, and oil is fed to the bearing by a wick, constant circulation of the oil being maintained as long as there is any oil remaining in the oil well. Good, light oil should be poured into the oil well to the level of the oil inlet every 1,000 miles. To the bearing oilers of the starting motor should be given a few drops of oil at the same time.

The bearings of the starting motor and the generator of the Bijur system should receive a few drops of thin, neutral oil, such as *3 in 1*, every two weeks.

The bearing at the driven end of the generator of the Wagner system is usually oiled by splash lubrication from the engine, and the commutator end bearing is provided with an oil opening. In other types, there are oil holes at each end of the generator. Wherever oil holes are provided, a few drops of good machine oil should be put in them once every week while the car is running.

The Wagner starting motor has an oiler at the front end into which a few drops of machine oil should be placed every 500 miles. The rear armature bearing and the countershaft bearing are located in the reduction gear box, and receive sufficient lubrication from the grease contained in this casing. Gredag is the form of grease recommended for use in this gear casing into which it can be injected by an ordinary grease gun, after the small threaded plug provided for this purpose has been removed.

In Delco dynamotors, both the generator and motor overrunning clutches should be disassembled, cleaned, and repacked each season with light cup grease or vaseline. A failure to keep these two points lubricated properly, may result in the sticking of the clutch and serious injury to the armature. A grease cup or grease-gun fitting is usually placed on the end of the shaft carrying the starter gear, and grease should be forced through the hollow shaft into the clutch, after each 1,000 miles. Oilers are provided for the bearings of the

dynamotors, and four or five drops of good cylinder oil should be placed in them every 500 miles. In the dynamotor used in the Buick four-cylinder car, it is necessary to remove the diagonal cover plate at the rear of the machine to expose to view the oil hole leading to the rear armature bearing.

The starter of the Atwater-Kent system has an oiler at each end of the armature, while there is a single oiler in the generator. This oiler is located at the commutator end of the housing. Every 1,000 miles, a few drops of good cylinder oil should be placed in these oilers.

In the Ford starting-and-lighting system, the starting motor is lubricated by the engine splash system. The generator is lubricated by the oil splash from the timing gears. An oil cup is also provided at one end of the generator housing, and a few drops of cylinder oil should be applied at regular intervals.

31. It is very important that an excess of lubrication on the starter or generator bearings be avoided. Excess oil works its way on to the commutator, and in a short time will cause the machine to become inoperative on account of short-circuited armatures. If any oil has found its way to the commutator surface, it should be wiped off with a clean cloth moistened with gasoline. The brushes should be removed and washed with gasoline. Plenty of time must be allowed for the complete vaporization of the gasoline and the clearing away of these vapors before the engine is run again. Otherwise, the vapor may be ignited by sparks from the brushes and cause a fire.

32. Springs.—Spring pivot and shackle bolts should be lubricated at regular intervals to prevent them from undue wear and noisy action. The sharp clicking noise made by some cars when running over rough places in the roads, can usually be traced to spring bolts that have become badly worn from neglected lubrication. Where grease-gun fittings or grease cups are provided, a little cup grease should be forced into the bearing every 250 miles. Where oil cups are used, a few drops of cylinder oil should be applied each day, or every 100 miles. In the Franklin car, in which wick lubrication is

used for the spring shackle bolts, it is sufficient to fill the oil reservoir with cylinder oil once a month. For winter use, a mixture of 50 per cent. kerosene and 50 per cent. oil is recommended.

Free play of the springs is impeded or prevented when the leaves are allowed to become rusty, and when this happens, the car is usually judged as having too stiff springs, instead of the trouble being ascribed to its true cause. To prevent this undue friction, as well as annoying squeaks and even breakage of the spring leaves, a suitable lubricant should be inserted between the spring leaves at fairly frequent intervals. The spring leaves are usually painted with a lubricant containing graphite by the makers, but this wears away in the course of time, letting the bare leaves rub on one another, and the lubricant must be renewed. The action of the springs can be improved by painting the edges of the leaves with a mixture of engine oil, kerosene, and graphite, the mixture being applied with a stiff brush. Some of the lubricant will work its way between the leaves while the car is running.

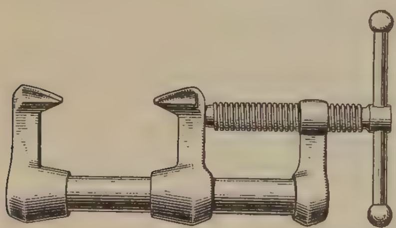


FIG. 11

33. Once every 1,000 miles, or so, the body of the car should be jacked up to remove the weight from the springs, and the spring clip nuts should be loosened. In jacking up the body, the jack must be placed underneath the car frame, and not under the axle. When the spring leaves are loosened, they should be separated one at a time by means of a wedge, and the working surfaces covered by a mixture of grease and powdered graphite. A spring spreader, such as in shown in Fig. 11, this device being manufactured by the Spring Leaf Lubricator Company, is a very convenient tool for separating the spring leaves, but is not absolutely essential.

Once each season it is a good plan to remove the springs from the car, and take them apart. Each leaf should then be

washed in kerosene to remove caked grease or rust, and the working surfaces smoothed up with sand paper. The leaves should be smeared with the grease and graphite mixture and the springs reassembled and replaced in the car.

There are many devices now on the market for lubricating spring leaves. Some of these are in the form of oil pads which are clamped to the side of the spring, and which filter oil in between the spring leaves. Others are in the form of spring covers combined with lubricating facilities, these having, in addition to their lubricating properties, the added advantage of keeping mud or dirt from the springs.

34. Miscellaneous Equipment.—Automobile electric horns require occasional lubrication to keep them in good working order. About once a month, a few drops of light oil, such as sewing machine oil or *3 in 1*, should be applied to the bearings at the ends of the armature, through oil holes provided for this purpose.

The makers of Gabriel snubbers recommend that the snubbers be disassembled and lubricated with graphite every 5,000 miles. In order to do this, it is first necessary to remove the snubber from the car, fasten it in a vise, and remove the housing. The coils of the belt are then unwound and the sleeve casting and sleeve are removed. The plunger which slides in the sleeve, as well as the sides of the sleeve casting where the casting rubs against the surface of the housing base, should be lubricated with the graphite grease. The inner sleeve is then replaced, making sure that the long arm is opposite the end of the snubber belt, where it is riveted, and the coil spring is packed with grease. The remainder of the snubber should be assembled in the reverse manner of its removal.

The speedoemter flexible shaft should be lubricated about every 4 months. In lubricating this shaft, neither cylinder oil nor hard grease should be used, because a thin oil will work out of the casing and leave the shaft dry, while a heavy grease will set up unnecessary friction. A specially prepared graphite grease is preferable for this purpose. To lubricate

the flexible shaft, it is a good plan, after removing it from its casing, to place a small quantity of the lubricant in a cloth and draw the chain through it, so that the lubricant will enter all spaces in the chain. In speedometer drives employing a swivel joint, this joint should be lubricated every 500 miles. A grease cup or grease-gun fitting is usually provided for this purpose. If this lubrication is not attended to, swivel joint trouble is inevitable.

No lubrication should ever be given to the speedometer head. Any parts in the instrument requiring lubrication were attended to when the device was assembled, and the lubrication will last the life of the instrument, as there is practically no wear.

A drop of oil now and then on the working parts of the windshield and foot-rails will keep them in good condition. The hinges and latches of doors should have a few drops of oil occasionally, but the cylinder or lock of Yale door locks must not be oiled. The oiling of door hinges and latches must be done with care and all excess oil should be wiped off, so that there will be no danger of soiling the clothing of the occupants of the car.

The plungers in the spark and throttle levers should be lubricated occasionally, as well as the small ball-and-socket joints in the carbureter and timer operating mechanism.

In addition to the places already mentioned, all of the small connections and joints throughout the car, such as the various brake-rod connections and joints in the brake connections, should be made note of and oiled as required. It must always be kept in mind that lubrication will reduce to a minimum the friction and wear between parts moving in contact, and will eliminate disagreeable squeaks and rattles that are always the result of improper lubrication

AUTOMOBILE-ENGINE LUBRICATION

LUBRICATION SYSTEMS AND DEVICES

LUBRICANTS

FRICTION AND LUBRICATION

1. No matter how smooth a metallic surface may seem to the sight or to the touch, it is in reality covered with very minute projections, so that the surface consists of ridges and hollows. These may readily be seen under a microscope. Thus, when two clean metallic surfaces are placed together, and motion is given to one or both of them, so as to cause one to slide or roll on the other, the little ridges engage one another, or interlock, so that there is a resistance to the motion. This resistance is called *friction*. The amount of friction depends on the pressure with which the two surfaces are held together, the materials of which the surfaces consist, and the condition of the surfaces. The movement of one surface over the other causes some of the small ridges to be broken off or torn loose from each surface. This tearing away or abrading of the metal is called *wear*.

2. Lubrication consists in introducing some substance, either liquid or solid, between two rubbing surfaces, to reduce the friction and the wear that would otherwise occur. The substance used, which may be oil, grease, graphite, or combinations of these materials, is known as the *lubricant*. When

it is put between the two surfaces, it spreads out and forms a thin layer, or film, that fills up the very small hollows in the surfaces and so prevents the metals from touching each other except at the points of the highest ridges. As a consequence fewer ridges can interlock, and so less effort is needed to move one surface over the other; in other words, the friction is decreased. As fewer ridges are broken off or torn loose, the wear is correspondingly lessened.

CYLINDER OILS

3. Characteristics.—The oils that are used as lubricants may be obtained from animal, vegetable, or mineral sources. All automobile cylinder oils are of mineral origin, having been distilled from crude oil. There are two oils of mineral origin, namely, *shale oil*, which is obtained from certain shales, and *mineral oil*, which is obtained from oil wells. Shale oil is not of much value as a lubricant and it will, therefore, not be considered further. Mineral oil as it comes from the wells is called *crude oil*. When it is heated, vapors are given off, which, when condensed, form various lighter oils that are called *distillates*. The process of driving off the different constituents of crude oil by heat is known as *refining*. The engine oils made in this country are refined from crude oil having either an asphaltic or paraffin base, depending on the section of the country from which they are obtained.

The heating of crude oil to a temperature but slightly above that of the atmosphere drives off vapors that form gasoline when they are condensed. A somewhat higher temperature drives off vapor that forms kerosene, and so on. Each increase in temperature drives off a different oil from those that have preceded and each oil is less fluid than the one that was obtained before it. After kerosene, a number of oils that are used for lubricating purposes are obtained. When the lighter elements have been driven off, the residue is drawn off, and is passed through a strainer to free it from grit and earthy matters. It is afterwards cooled and the wax removed. Heavy bodied oils, including steam-engine cylinder oil, are made

largely from this residual product. Many cylinder oils for use in internal-combustion engines consist of combinations, or blends, of distillate with the heavier residual stocks in varying proportions. Some lubricating oils are comparatively thin, whereas others are quite thick. All lubricating oils increase in fluidity when their temperature is raised; that is, they lose their body, or decrease in viscosity.

4. The thickness, or body, of an oil, commonly called its viscosity, is an important property in lubricating. The lower the viscosity—that is, the thinner the oil—so long as other conditions are satisfied, the better the oil for lubricating purposes. Some oils become so thin at high temperatures that they lose most of their lubricating properties. Mineral oils, when heated, lose their viscosity much more rapidly than animal or vegetable oils, but vegetable and animal oils burn more easily.

Mineral oils give off inflammable vapors when heated. The amount of these vapors is at first not sufficient to ignite, but at a certain temperature enough is given off to ignite with a flash, though the flame dies out almost immediately. The temperature at which the flash appears is called the *flash point*. Vapor is given off in sufficient amount to maintain a flame constantly when the temperature is raised somewhat above the flash point. This temperature is called the *burning point* or *fire point*. An oil is said to have a high fire-test or a low fire-test according as the burning point is high or low. The higher the viscosity of an oil, the higher is its fire-test. The fire-test of lubricating oil should, therefore, be as low as is consistent with safety under service conditions. When the flash point of an oil is 300° F. or higher, there is little danger of fire when handling it under ordinary circumstances. Oils that flash at a temperature much below 300° F. give off, at atmospheric temperature, inflammable vapors that increase the fire risk if the oil is stored where there is not free ventilation. The loss by evaporation is also greater from an oil of low fire-test than from one having a high fire-test. Lubricating oils do not, as a rule, flash at a temperature below 300° F., and they therefore do not offer very great danger of fire.

5. Properties.—There are three essential properties that a good gas-engine cylinder oil must possess.

1. It must have as high a fire-test as practicable; that is, the temperature at which it gives off inflammable vapor should be as high as is consistent with the desired body. In the best gas-engine cylinder oils, this temperature will be about 450° F., which gives a satisfactory factor of safety, inasmuch as the temperature of the cylinder walls of internal-combustion engines rarely rises above 250° F.

2. It must be of the best quality in respect to purity, cleanliness, and unformity. By this is meant that it must be free from acid, alkali, or any heavy residue that tends to form carbon deposit in the engine cylinders. Any cylinder oil will leave some carbon deposit, which gradually accumulates on the inner walls of the combustion chamber and on the piston head and valves, but it is desirable that this accumulation should be prevented as far as practicable. If it becomes thick, especially if the compression is high or if the form of the combustion chamber is such that sharp corners are exposed to the heat of the flame, particles of the unburned carbon clinging to the walls or elsewhere may become heated to such a degree as to ignite the charge before compression is complete. Also, every drop of oil must be the same as every other drop.

3. The third requirement of a good gas-engine cylinder oil is that it shall have the proper body. If the oil is too heavy, it will not work past the piston rings in sufficient quantity, while if it is too light, the high temperature of the cylinder will reduce its viscosity and make it too thin to be used satisfactorily as a lubricant.

6. Grade of Oil.—For ordinary water-cooled engines, some engine makers recommend the grade of cylinder oil known as *heavy* for summer use. In weather cold enough to cause this oil to stiffen, the next lighter grade, or *medium*, may be employed. In cold weather it is the custom to use a special oil that will not become too thick at low temperatures. Other engine makers recommend that the same kind of oil be used all the year around. On account of this difference of

opinion, it is advisable, when in doubt as to what grade of oil to use, to inquire of the manufacturer of the car or the engine, who usually will be glad to advise what brand of oil he recommends for his engines. This information is also often given in the instruction books furnished by many car manufacturers.

In air-cooled cylinders, the operating temperature is usually considerably higher than in water-cooled engines, and only the heaviest oil obtainable and with the highest possible fire-test should be used. Many oil refineries make a special oil suitable for air-cooled engines, which is put up in tin cans plainly marked to that effect. Oil suitable for water-cooled engines does not have a sufficiently high fire-test to permit its use in air-cooled engine cylinders, where the cylinder temperature is very high.

Some manufacturers of automobiles sell oils, marked with their own labels, that they recommend for use in their engines.

7. As an example of what are considered suitable oils for automobile engine use, the specifications of the manufacturers of the Hollier eight-cylinder engine are here quoted:

For summer use, oil should have a specific gravity of between 30 and 32 degrees Baumé at plus 60 degrees Fahrenheit; a flash test of 440 degrees Fahrenheit, or higher; a fire-test of between 490 and 500 degrees Fahrenheit; a viscosity of 90 at 212 degrees Fahrenheit (Tagliabue viscosimeter); and a cold test, or resistance to solidification by cold, of plus 10 degrees Fahrenheit.

For winter use in localities where the temperature drops below plus 20 degrees Fahrenheit, oil should have a flash test of 360 degrees Fahrenheit, or better; a cold test of minus 10 degrees Fahrenheit, or lower; and a viscosity not above 200 at 70 degrees Fahrenheit. The oil should be filtered, not acid treated.

8. The **viscosity,** or degree of fluidity, of an oil is measured by an instrument called a **viscosimeter.** The two viscosimeters in most common use are the Saybolt and the Tagliabue instruments. Both of these, in conjunction with a stop-watch, give the time required for a certain quantity

of oil at a known temperature to flow through a nozzle of a given size.

The Saybolt viscosimeter is used by the Standard Oil Company, and by nobody else; when it is used it expresses the viscosity by the number of seconds it takes 60 cubic centimeters (3.66 cubic inches) of the oil to pass through the measuring nozzle of the instrument. Thus, if it takes 45 seconds to discharge 60 cubic centimeters of oil having a temperature of 210° F., the viscosity is *45 at 210° F. on the Saybolt instrument.*

The Tagliabue viscosimeter is used by independent oil refiners. The viscosity of oil tested by it is indicated, in practice, in two ways. In the one case, the viscosity is taken as twice the number of seconds it takes 50 cubic centimeters (3.05 cubic inches) to pass through the measuring nozzle; thus, if a sample of oil tested at 210° F. takes 45 seconds to pass 50 cubic centimeters through the nozzle, the viscosity is *90 at 210° F. on the Tagliabue instrument.* In the other case, the viscosity is expressed directly as the number of seconds it takes 50 cubic centimeters to pass the nozzle; thus, taking the same case as before, the viscosity is *45 seconds at 210° F. on the Tagliabue instrument.*

The different viscosimeters in use do not register viscosity alike; consequently, when the viscosity of an oil is given, it must be known with what instrument it was measured.

9. Maintenance of Quality.—When having the oil supply in the crank-case replenished, especially at a roadside service station where the business carried on is mostly of a transient nature, a specific kind and grade of oil should be asked for. If this oil is not carried in stock, see that an oil of equally good quality is substituted. If this is not done, there is considerable likelihood of obtaining oil of a grade not suitable for the engine, or even a very poor quality of oil. The substitution of inferior oils, when the purchase is made from irresponsible dealers, is an evil with which the operators of automobiles must constantly contend. The only safe policy is to buy well-known standard brands of oil. If the price charged for a certain brand of oil is abnormally low in com-

parison with what is asked for oil of recognized quality, it is safe to assume that the quality of the oil is lowered in practically the same proportion as the price.

Having procured the proper lubricant, the next step is to make sure that all of the means provided for the application of the oil to the points where it must perform its functions are in working order. This means, of course, being sure that, at all times, the distributing system is kept clean, free from all obstructions, and the working parts kept in a condition where they will properly function.

The next thing is to insure that the oil supply is renewed often enough to have thoroughly efficient oil supplied to the bearings at all times. From the beginning of the time when an engine is operated on a fresh supply of oil, the oil in the crank-case begins to depreciate in efficiency to whatever extent it may be contaminated by the introduction of foreign non-lubricating matter. These contaminating influences include largely the following:

1. Gasoline condensed from over-rich explosive mixtures. This gasoline is forced between the packing rings and the walls of the cylinders on the compression stroke of the piston and finds its way into the crank-case.

2. Water of combustion in rather considerable quantities, especially in cold weather, will find its way between the piston rings and the walls of the cylinders upon the compression stroke of the pistons, principally in the form of steam which condenses in the crank-case. Water sometimes finds its way into the combustion chamber, also, from a leaky cylinder-head gasket, whence it passes on to the crank-case. The water may, moreover, enter the crank-case directly through the breather pipe through carelessness in washing the car.

3. *Carbon Deposits*.—These are due largely to the collection of unconsumed carbon in the explosive mixture, which is collected by the lubricating oil upon the piston heads and in the clearance spaces and combustion chambers of the engine, and is carried in part past the piston rings with the condensed gasoline, as stated in (1).

4. *Road Dirt*.—Dust and other foreign elements in the air find their way into the cylinders through the air intake of the carbureter, and also directly into the crank-case through the breather funnel.

10. Analysis of a number of samples of oil taken from the crank-cases of automobiles, after the oil had been depreciated in quality to such an extent as to render it unfit for further use, showed, in some cases, as high as 62.8 per cent. of gasoline and water, 7.2 per cent. of carbon, road dirt, etc., and only 30 per cent. of efficient oil.

The rapidity with which the oil becomes contaminated and inefficient will vary greatly in different engines. If an engine is equipped with an oil ring on the lower end of the piston, it will show a considerably less tendency to accumulate the foreign substances before mentioned, than one without this ring, and such an engine will also have a decreased tendency to accumulate carbon deposits on the piston heads and in the combustion chambers of the cylinders. This last condition is due to the fact that the oil ring has a tendency to prevent excess lubricating oil from accumulating on the piston head and in the cylinder clearances, which, in turn, lessens the tendency of the unburned carbon from the gasoline to collect where it can be forced past the piston rings into the crank-case. It is obvious that the less lubricating oil allowed to accumulate in the combustion chambers of an engine, the less will be the tendency for the unburned carbon to collect in the combustion chambers, and the greater will be the tendency for the unburned carbon to pass out with the exhaust gases.

Naturally, the accuracy with which the piston rings fit the cylinder bore, and the condition of the rings in their grooves greatly influence the degree to which the foreign substances pass between the piston rings and the cylinder walls and into the crank-case, as well as the extent to which the lubricating oil will find its way into the combustion chamber. A concrete illustration of this is seen when the engine is running idle, that is, with the throttle closed as far as is possible and still permit-

ting the engine to run. In this case, upon the intake stroke of the engine, there is a partial vacuum created in the cylinder, which is not completely filled by the quantity of explosive mixture allowed to enter the cylinder through the nearly closed throttle. The creation of this partial vacuum has a tendency to draw the lubricating oil up past the piston rings into the combustion chamber, and thus causes an excessive accumulation of lubricating oil which serves as a medium for collecting unburned carbon from the explosive mixture. This carbon, in turn, is forced in part back past the piston rings into the crank-case, on the next compression stroke of the engine.

11. Some manufacturers of automobiles and manufacturers of lubricating oils advocate the drawing off of the entire contents of the crank-case, and the refilling of the case with fresh oil for each specified number of miles run; some will recommend that it should be done after every 500 miles that the engine runs, and others will specify shorter or longer distances. This method of assuring efficient lubrication may be satisfactory in certain cases, as, for instance, where the operator is fully familiar with the condition and requirements of his own particular car, but, in general, the variation in periods, or distances run, will be so great, under different conditions and in different engines, that no set rule can be established which will be thoroughly reliable. All manufacturers are agreed, however, that the oil must be changed oftener when the car is new, and the engine is going through its *running in* period, than is necessary under normal conditions.

The oil-level indicator on the engine serves to show the height of the oil in the crank-case, but is no indicator of the quality of the oil. On this account, it is often misleading, especially to inexperienced automobile operators, whose efforts are mainly directed toward maintaining the proper oil level in the crank-case. Because of the presence of extraneous matter, as already described, it frequently happens that the crank-case will contain a plentiful supply of oil, when, as a

matter of fact, the value of this oil, as a lubricating medium, is practically zero.

The best method of determining the condition of the oil in the crank-case, from a standpoint of lubricating efficiency, is to draw off a small quantity of the oil containing the impurities mentioned and test its specific gravity with a hydrometer. If the specific gravity of the original oil is known, the degree to which it has depreciated can be practically determined by the extent to which the specific gravity has decreased, which is, of course, the increase in the number of degrees Baumé shown by the hydrometer. Another indication of the condition of the lubricating oil in the crank-case is the pressure maintained in the lubricating systems, as indicated by the oil-pressure gauge found upon the cowl boards of practically all automobiles. When an entirely new supply of fresh oil is introduced into the crank-case, the oil-pressure gauge will indicate a maximum pressure according to the viscosity of the oil used, and the temperature of the oil in the crank-case, when the engine is running at a uniform rate of speed. The longer the oil is kept in the crank-case without renewal, the more the pressure indicated on the gauge will be decreased, due to the thinning out of the oil by the accumulation of gasoline in the crank-case. This method, of course, applies only to cases where the automobile is being run at a comparatively uniform speed, say between 20 and 25 miles per hour, and is, therefore, only approximate, but it is a method which is easily and readily available to the average operator of an automobile, who has neither the time nor the opportunity to have his problems worked out for him in laboratories.

LUBRICATION SYSTEMS

CLASSIFICATION

12. The three different systems by which the moving parts of automobile engines are supplied constantly with oil while the engine is running may be divided into *splash lubrication systems*, *pressure-feed lubrication systems*, and *combined splash and pressure-feed lubrication systems*.

SPLASH LUBRICATION SYSTEMS

13. In the splash lubrication system, the lower part of the crank-case contains cylinder oil into which a projection on the lower end of the connecting-rod dips at every revolution, churning the oil into a dense mist and throwing it all over the internal surfaces of the engine. There have been various applications of the splash lubrication in the past, but at present the splash system in common use is that known as the *circulating constant-level splash system*, or, more commonly, as the *circulating splash system*. In this system, the oil is transferred from a reservoir in much larger quantities than is needed, into troughs placed beneath the connecting-rods from which troughs the oil overflows back to the reservoir, whence it is sent back to the troughs again. The oil is thus continually circulated. In some circulating splash systems, the troughs are formed in the bottom of the crank-case, and the oil reservoir is not located directly in the crank-case. In other systems, the oil reservoir is located in the bottom of the crank-case, and separate troughs are used, one under each connecting-rod, the oil reservoir then being open at the top. In still other systems, the oil reservoir, when in the bottom of the crank-case, is closed on top by a horizontal partition in which the troughs are formed, each trough having an overflow through which surplus oil flows back to the reservoir.

Openings are provided in the projections used on the lower ends of the connecting-rods in splash systems. These holes

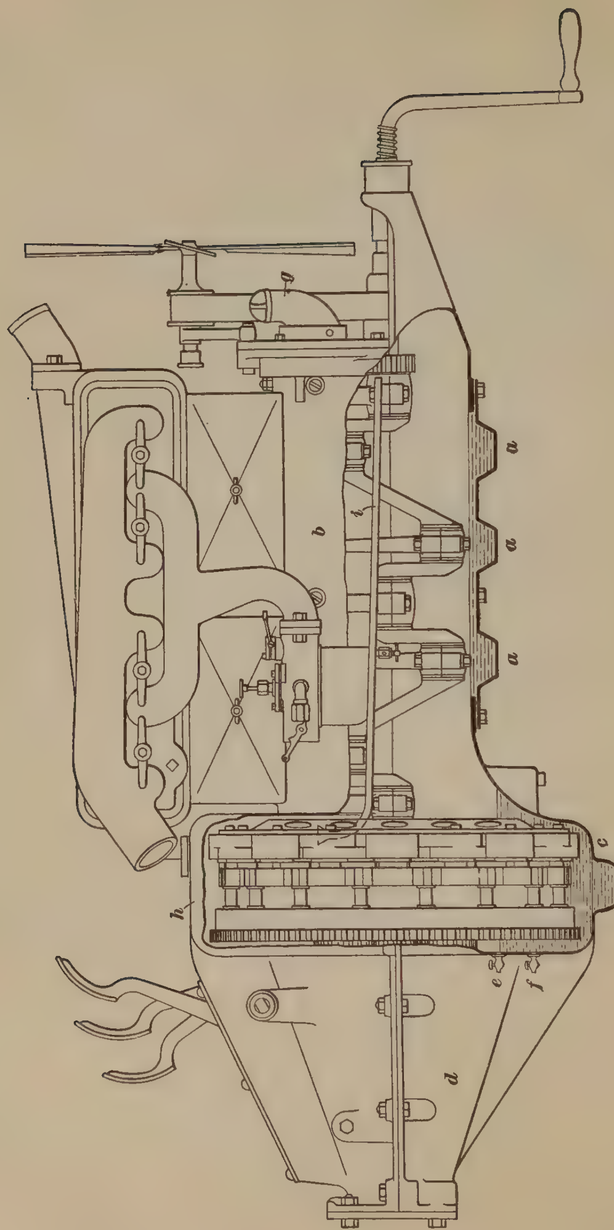


Fig. 1

communicate with the connecting-rod bearings, thus insuring plenty of lubricating oil on these bearings at all times.

14. The oiling system used in the engine of the Ford, model T, automobile is the simplest form of a circulating splash system, and is characterized by the absence of a pump for circulating the oil; it is shown in Fig. 1. There are three troughs *a* formed in a removable plate at the bottom of the crank-case *b*; in the earlier model T engine these troughs were formed directly in the crank-case. The connecting-rods of the first, second, and third cylinders dip into oil with which these troughs are continually being filled, splashing this over the cylinders and bearings. To the rear of the lower crank-case *b* is the lower flywheel and magneto housing *c*, and to the rear of this the lower clutch and transmission housing *d*, both of which are in one piece with the lower crank-case. The lower housing *c* forms the oil reservoir, which is supposed to be filled with oil to the level of the upper gauge cock *e*, and to be refilled as soon as the oil level has dropped below the level of the lower gauge cock *f*. This oil reservoir is filled by pouring oil through the crank-case breather pipe *g*, whence it flows along the bottom of the crank-case *b* to the reservoir *c*. The cap shown covering the breather pipe has openings in it communicating with the atmosphere; these openings cannot be seen in the illustration. The flywheel, with the horseshoe-shaped magnets of the magneto that are attached to it, dips into the oil in the housing *c*, and when the engine is running throws oil into the upper flywheel housing *h*. Some of the oil drops by gravity into the funnel-shaped opening of the oil-circulating pipe *i*, which leads to the timing gears at the forward end of the engine, whence it drops to the forward end of the lower crank-case and in flowing back to the reservoir *c* keeps the three troughs *a* filled. The fourth cylinder, together with its working parts, is lubricated by splash directly from the reservoir *c*. Some of the oil thrown into the upper flywheel housing *h* flows to the rear, oiling the transmission and universal joint of the driving shaft, returning along the sloping bottom of the transmission housing *d* to the reservoir *c*.

15. The circulating splash-lubrication system used in the engine of the Chevrolet "490" automobile is shown in Fig. 2. In this system, a gear pump is employed for circulating the oil, and its operation is typical of all engines in which an oil spray, thrown up by the dipping of the lower ends of

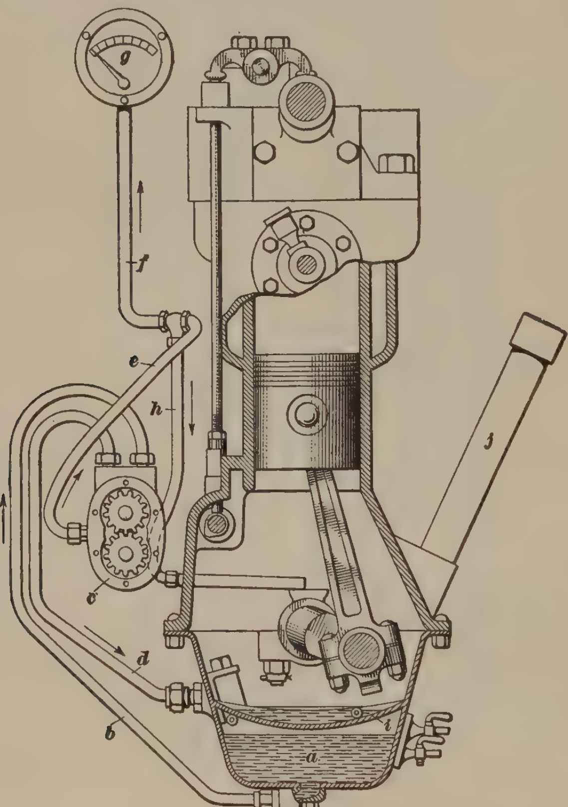


FIG. 2

the connecting-rods into the oil troughs, is depended upon almost entirely for lubricating the internal working parts of the engine. The oil reservoir *a* is formed in the lower crank-case, and is connected by the pipe *b* to the gear pump *c* which is located on the end of and driven by the generator drive shaft. From the oil pump, another pipe *d* leads to a

connection on the side of the crank-case. Still another pipe *e* leads from the pump *c*, one branch *f* of this pipe being connected to the oil-pressure gauge *g* and the other branch *h* passing into the crank-case so as to discharge into a funnel-shaped opening above the center main crank-shaft bearing. Four oil troughs *i* are provided, one directly under each connecting-rod, into which the projections, or splashers, on the ends of the connecting-rods dip at each revolution of the crank-shaft.

When the engine is running, the gear pump *c* draws the oil from the oil reservoir *a* through the suction pipe *b*, and forces it into the two oil-delivery pipes *d* and *e*. The oil passing through the pipe *d* enters the crank-case above the level of the splash troughs, and is distributed to the four troughs through small tubes. The oil is supplied to these troughs in much larger quantities than is needed, and holes are provided to keep the oil at the proper level, and allow the excess to drain back into the oil reservoir. The rapid splashing of the ends of the connecting-rods in the oil in the oil troughs keeps the main bearings, connecting-rods, piston pins, and cylinder walls bathed in oil.

The oil passing through outlet pipe *e* runs into the funnel above the center main bearing and floods this bearing with oil, the excess running down into the oil reservoir. The pressure of the oil in the pipe *f* is registered by the oil gauge *g*, which gives the driver a constant and ready means of observing the action of the pump.

The pipe through which the oil is poured into the reservoir is shown at *j*.

16. In some circulating splash-lubrication systems, oil is pumped to some of the bearings, as, for instance, the cam-shaft and crank-shaft bearings, but the oil does not circulate through these bearings under pressure. Such systems are not classified as combined pressure-feed and splash systems. A system of this kind is used in the Dodge engine, and is shown in Fig. 3 (*a*) and (*b*). When the same parts are shown in each view, the same reference letters are used, and both views should be referred to in studying the description.

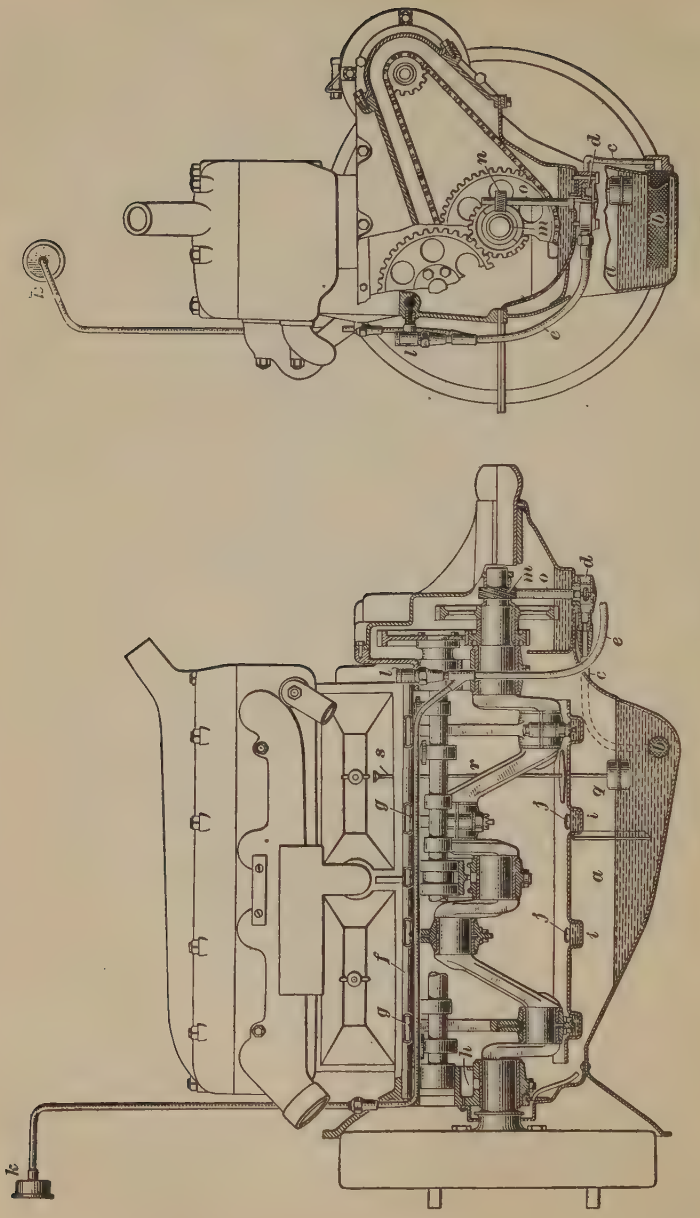


FIG. 3

The oil in the reservoir *a* is drawn through the oil strainer *b*, which is located in the lowest part of the crank-case, through the pipe *c*, to the oil pump *d*. From the oil pump, the oil is forced through the pipe *e* to a pipe *f* running along the top right corner of the crank-case, and is sprayed through the holes *g* into pockets, thus lubricating the cam-shaft bearings. The crank-shaft bearings are lubricated by the oil pockets *h* which are supplied from the cam-shaft bearing pockets through channels cast in the cylinder block. Other holes in the oil-feed pipe *f* allow jets of oil to flow down into the four oil-pan troughs *i* which are located directly beneath the four connecting-rods. The spray created by the splash of the dippers on the ends of the connecting-rods passing through the oil troughs, lubricates thoroughly all of the moving parts, including the piston-pin bearings, connecting-rod bearings, piston and cylinder walls, cams, and valve lifters. The overflow from these troughs passes through openings *j* into the oil reservoir. The oil pressure gauge *k* registers the pressure in the oiling system, and shows whether the lubricating system is operating properly. A ball check-valve is provided at *l* which prevents the pressure of the oil from exceeding a given maximum. The oil pump *d* is driven by the crank-shaft by two spiral gears *m* and *n*, and the vertical shaft *o*.

PRESSURE-FEED LUBRICATION SYSTEMS

17. In a pressure-feed lubrication system, as implied by the name, the oil is supplied to the rubbing surfaces under pressure. In the strictest sense, the oil would be supplied to all rubbing surfaces under pressure; as carried out in some systems, however, oil under pressure is supplied only to the crank-shaft main bearings, crankpins, and timing gearing. In other systems oil under pressure is supplied to the cam-shaft, also. In both these systems the oil thrown off from the crank-pins is usually relied upon to lubricate the surfaces, such as cylinder walls, wristpins, etc., not supplied directly with oil under pressure. In some cases, oil is supplied to all of the rubbing surfaces under pressure, and such systems are generally referred to as *full-pressure systems*.

18. A pressure-feed lubrication system in which nearly all of the moving parts of the engine are positively lubricated, is used in the Marmon automobile. In this system, a hollow crank-shaft is employed, through which the oil is forced to the main and connecting-rod bearings. The front cam-shaft bearing receives its lubrication from the front main crank-shaft bearing through an interconnecting oil hole provided in the crank-case casting; the rear cam-shaft bearing is lubricated directly from the oil pump; while the third, or middle, bearing is lubricated by the oil draining from the valve tappets. The valve tappets, valve lifters, and timing gears are lubricated by the excess of oil supplied to the overhead rocker arms, while pipes running up the connecting-rods to the piston pins take a portion of the oil from the crankpins to the piston pins, lubricating these positively and effectively. The oil passing out at the ends of the piston pins provides abundant lubrication for the cylinder walls and pistons. The oil circulation is shown in Fig. 4, which is a skeleton perspective view of the lubrication system used in the Marmon engine. The oil is poured through the filler or breather *a* on the top of the engine, into the reservoir *b*, where the reserve supply is carried below the range of the connecting-rods. From this reservoir the oil is drawn through the strainer *c* and pipe *d* to the oil pump *e*, which is located at the rear end of the engine just back of the cam-shaft. The bearing for the oil pump has a groove along the top through which a slight amount of oil escapes under full pump pressure to the pump coupling and rear bearing *f* of the cam-shaft *g*. From the oil pump, all of the oil, except that which escapes to the pump coupling and cam-shaft bearing, passes through the pipe *h* to the rear crank-shaft bearing *i*, and, from this bearing, directly into the hollow crank-shaft *j*. As the oil travels through the crank-shaft under pressure, a part is forced out through openings to the main bearings, connecting-rod bearings, and thence through pipes on the connecting-rods to the piston bearings. It will be noticed in the illustration that large openings are hollowed out of the crank-shaft at the bearings, and these spaces form oil reservoirs which insure an excess of

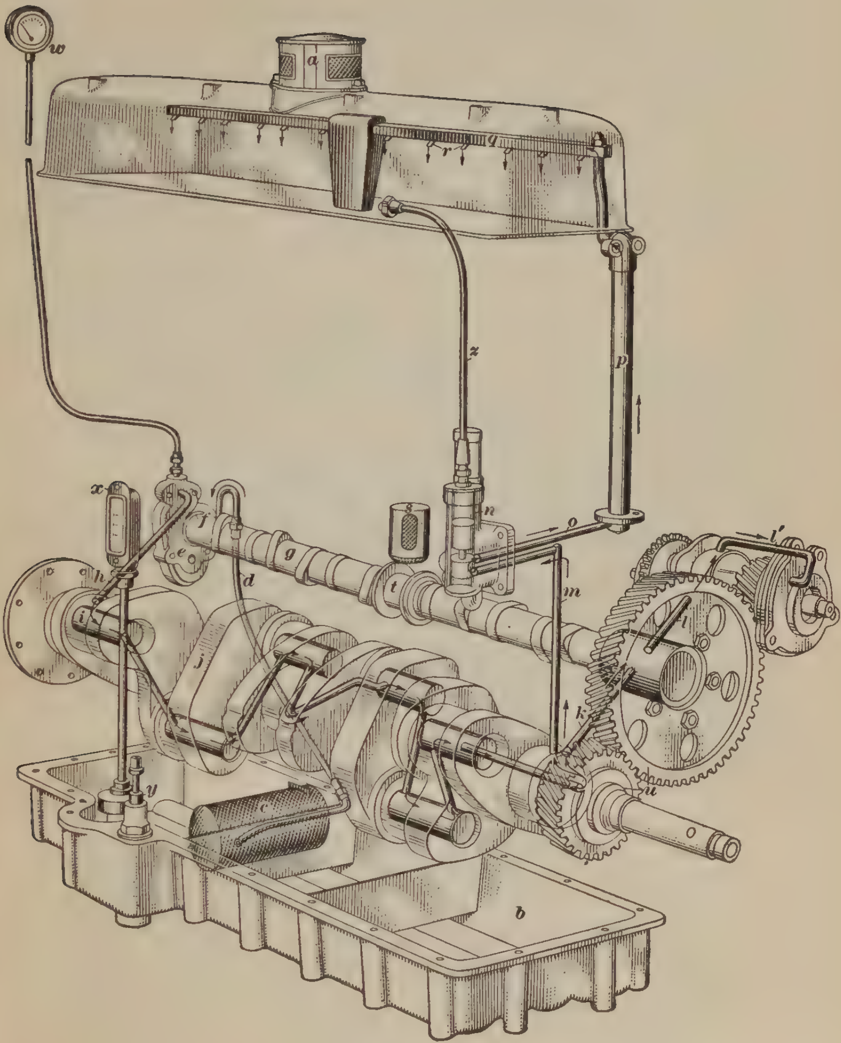


FIG. 4

oil being supplied to these bearings. At the front main bearing, the oil passes out of the crank-shaft, part going to the front cam-shaft bearing through the pipe *k*, thence to the front and rear generator ball bearings through the pipes *l* and *l'*, and another part passes through pipe *m* to the oil-pressure regulator *n*. From the regulator, the oil continues to circulate through the pipe *o* with its vertical rise pipe *p*, pipe *p* being the only external pipe in the entire lubricating system, thence through a square pipe *q* to the rocker arms of the overhead valve arrangement. Small openings *r* in the pipe *q* allow the oil to flow directly to the rocker-arm bearings. From the rocker arms, the oil flows down the side of the engine, and lubricates the valve push rods and tappets. A part of the oil which drips from the valve tappets is filtered through the screen *s* and passes to the middle cam-shaft bearing *t*, supplying plenty of lubrication at this point, and the remainder goes to the timing gears *u*, and then drains back to the oil reservoir *b*. A pipe *v* leads from the oil pump *e* to the oil-pressure gauge *w*, and this gauge indicates whether the pump is working or not, and shows the general condition of the lubrication system. The gauge *x*, known as an *oil-level gauge*, registers the height of the oil in the oil reservoir. The valve *y*, which can be opened or closed readily from above, permits of the draining of the oil from the reservoir, without crawling underneath the engine. The oil regulator *n* is connected by the pipe *z* to the intake manifold of the engine. The action of this regulator will be explained under the heading Oil Regulators.

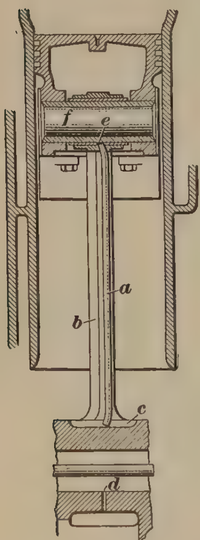


FIG. 5

19. The method of lubricating the piston-pin bearings in the Marmon and other engines in which lubrication is provided by what may be called the full-pressure system, is illustrated in Fig. 5. A pipe *a* is fastened to the web of the connecting-

rod *b*, and carries the oil from the connecting-rod bearings to the piston pins. An opening *c* in the upper connecting-rod bearing registers with the opening *d* of the crankpin at each revolution of the crankshaft, and oil passes up through the pipe *a* and opening *e* in the piston-pin bearing to the piston pin *f*. The oil from the piston-pin bearings, as well as that

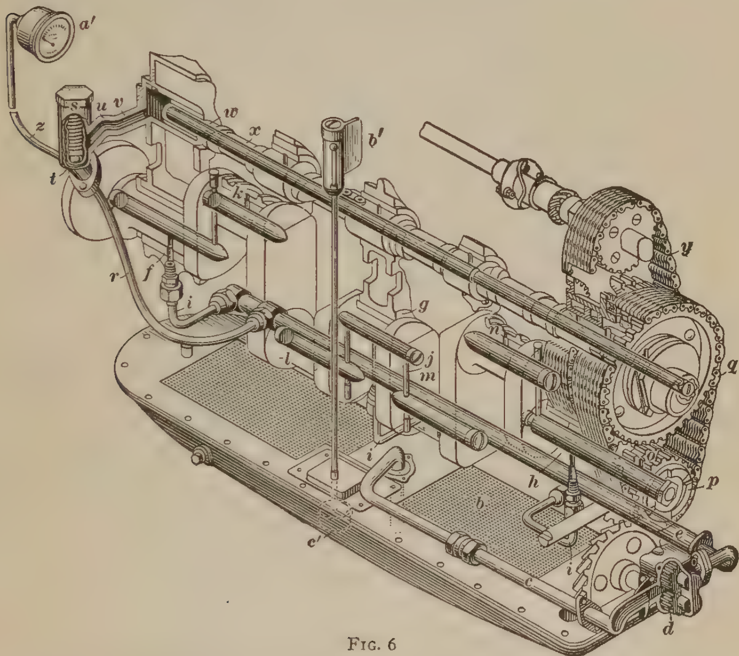


Fig. 6

thrown up from the lower ends of the connecting-rods, insures a thorough lubrication of the cylinder walls and pistons.

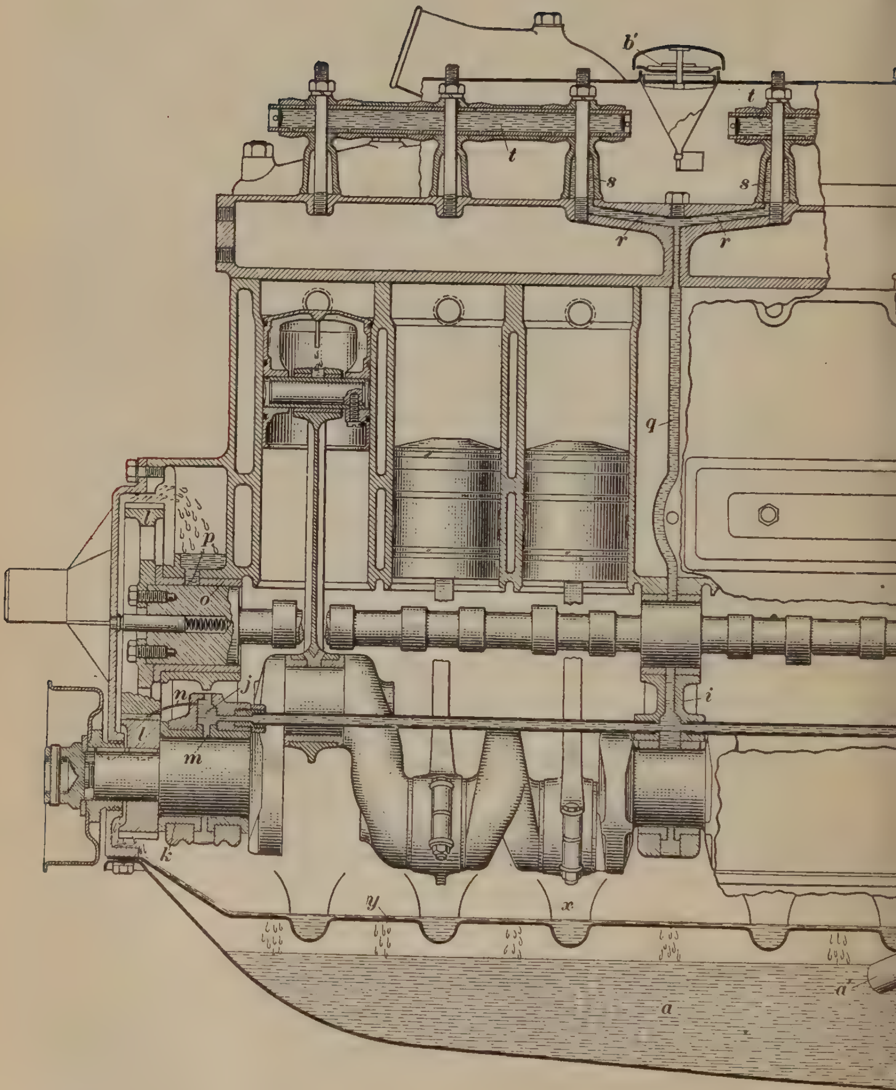
20. A pressure lubrication system in which the oil is forced through holes drilled in the crank-shaft and the cam-shaft under high pressure, to their respective bearings, is used in the engine of the Cadillac automobile. A skeleton view of the lubrication system used in this engine, as well as the main points covered by the system, is shown in Fig. 6. The oil supply is carried in the oil reservoir in the usual way, the reservoir being protected by the screen *b* through which all oil

passing to it is strained. The oil is drawn from the reservoir through the pipe *c* by the gear-pump *d*, which is driven from the water pump shaft by means of helical gears. From the pump, the oil passes into the supply pipe *e* whence a part goes to the main crank-shaft bearings *f*, *g*, and *h* through suitable pipes *i*. From the main bearings, the oil is forced to enter the crank-shaft through holes communicating with passages *j* in the interior of the shaft, and flows through these passages to the connecting-rod bearings *k*, *l*, *m*, and *n*, thoroughly lubricating these bearings. A hole *o* drilled in the forward end of the crank-shaft, communicates with a similar hole drilled in the crank-shaft sprocket gear *p* through which oil is supplied to the cam-shaft driving chain *q*.

A part of the oil passing through the supply pipe *e* flows through the branch *r* to the oil-pressure regulator *s*. A small hole, not shown, allows oil to flow around the ball check-valve *t* when it is seated, and this oil together with that forced past the valve, is carried by the elbow *u* and connection *v* to the rear cam-shaft bearing *w*, whence it enters the hollow cam-shaft *x*. From the hollow cam-shaft the oil, still under pressure, passes through small openings to the cam-shaft bearings, flooding these bearings with oil, and a hole in the end of the cam-shaft serves to lubricate the air pump of the gasoline system, not shown in the illustration, and the front driving chains *q* and *y*. A connecting pipe *z* leads from the oil-pressure regulator *s* to the gauge a' on the instrument board, which gauge registers the oil pressure in the lubrication system. An oil-level gauge b' operated in the usual way by the float c', shows the amount of oil in the reservoir.

COMBINED SPLASH AND PRESSURE SYSTEM

21. In some automobile lubrication systems, the oil is fed to certain moving parts under pressure from a pump, while the remaining parts are lubricated by the oil mist created by the splashing of the ends of the connecting-rods in the oil troughs. Different combinations of the splash and pressure systems are in use, the difference being mainly in the extent



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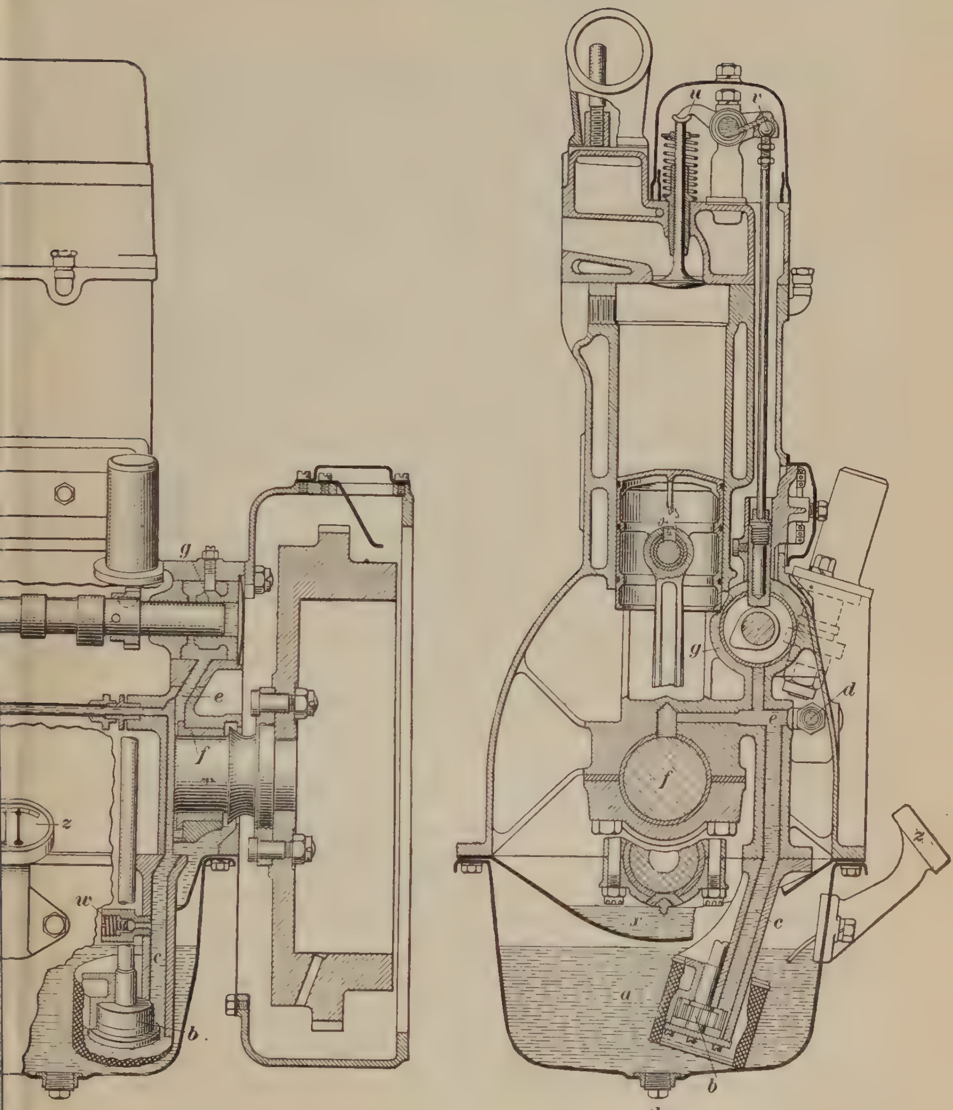

FIG. 7

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to which the bearings are lubricated by pressure or by splash, but the method of application is practically the same in all cases.

A typical example of the combined splash and pressure lubrication system is shown in Fig. 7 (*a*) and (*b*), which illustrates the Walker engine used in the Grant automobile, parts of the engine being cut away, as necessary, to disclose the lubrication details. The oil in the reservoir *a* is pumped by the oil pump *b* to the cored passage *c* whence a part passes into the main supply pipe *d* which runs lengthwise of the engine, and the remainder passes through the opening *e* flooding the rear crank-shaft bearing *f* and the cam-shaft bearing *g* with oil. In the middle of the main supply pipe *d* there is a passage *i* which conveys oil from the supply pipe to the middle crank-shaft and cam-shaft bearings. At the front end of the engine, the supply pipe *d* empties into a small reservoir *j* directly above the front crank-shaft bearing. From this reservoir the oil, still under pressure, is forced to the crank-shaft bearing *k* and the timing gears *l* by passages *m* and *n*, respectively. Oiling of the front cam-shaft bearing *o* is provided for by the reservoir *p* cast in the gear-case above the bearing. Oil from the timing gears is thrown into this pocket, and drains into the bearing.

The middle cam-shaft bearing is grooved and oil passes around it and thence through the pipe *q* and drilled openings *r* to No. 3 and No. 4 rocker-arm supports *s*. These supports are cored and drilled to permit oil to be forced up through them to the front and rear rocker-arm shafts *t*. These shafts are made hollow and have holes registering with the rocker-arm bearings. The rocker arms *u*, Fig. 7 (*b*), are also drilled so as to allow a flow of oil to the tops of the push-rod adjusting balls *v*. The pressure of oil carried through the entire pressure system is governed by a regulator *w* assembled to the pump.

The surplus oil from the pressure lubricating system drains into the oil troughs *x* beneath the connecting-rods, and the connecting-rod bearings, piston-pin bearings, and cylinder walls are lubricated by the oil thrown up by the projections on the lower ends of the connecting-rods. The overflow from the oil troughs drains back into the oil reservoir *a* through

holes in the splash pan y. The height of the oil in the reservoir is indicated by the gauge z which is operated by the float a'. New oil is poured into the oil filler b' in the top cover of the engine, and then flows over the top of the cylinder head and through the push-rod bushings to the oil reservoir. A connection, not shown, leads from the pump to the pressure gauge on the dash and keeps the driver informed of the operation of the lubricating system.

LUBRICATING OF OVERHEAD-VALVE MECHANISM

22. There are methods of lubricating the rocker arms in overhead-valve arrangements, other than by positive circulation of the oil through a hollow rocker-arm shaft, as described in connection with the Marmon and Grant systems. In the Nash engine, for instance, there is a space between the engine block and the side cover over the valve operating rods, and the rockers which operate the valves receive lubrication from the mist which condenses on the top of the valve cover and drops into special recesses machined over the friction points of each rocker. In the Buick engines, the shaft on which the rocker arms have their bearings is hollow, and this space is filled with felt wicking. The rocker arms are also recessed on one side and are filled with wicking. The wicking in the shaft and rocker arm is saturated with oil, which lubricates both the rocker-arm bearings and the point of contact between the rocker arm and the ball on the top of the valve push rod. In still other engines, oil holes are provided in the rocker arms, and oil must be supplied to the bearings from a hand oil can at short intervals to prevent undue wear and preserve quick operation.

LUBRICATION DEVICES

OIL PUMPS

23. The oil pumps used with automobile engine lubrication systems can be divided into four general classes, which are *gear-pumps*, *sliding-vane pumps*, *plunger force pumps*, and *lifting pumps*. Other classes of pumps have been used in some rare cases, but, broadly speaking, the four classes enumerated cover the oil pumps in actual use.

24. A **gear-pump** consists of two spur gears in a suitable housing and driven from some rotating part of the engine; this form of pump is probably more widely used than any other on account of its simplicity and reliability of action. In Fig. 8 is shown a top view of a pump of this type, with the cover removed to show the interior construction. There are two meshing spur gears *a* and *b* on shafts having bearings in the housing *c*; the gear *a* is driven from the engine in the direction of the arrow marked on it and drives the gear *b*. The housing *c* closely fits one-half the circumference of each gear, and in conjunction with the two gears forms an inlet chamber at *d* and an outlet chamber at *e*. The oil inlet to the pump is at *f* and this opening communicates through a port *g* with the inlet chamber *d*. The port *h* in the outlet chamber *e* communicates with the oil outlet *i*. Rotation of the two gears in the direction of the arrows marked on them takes oil from the inlet chamber and carries it around the semicircular parts of the housing to the outlet chamber whence it passes out by way of the outlet *i* to the main supply pipe of the engine.

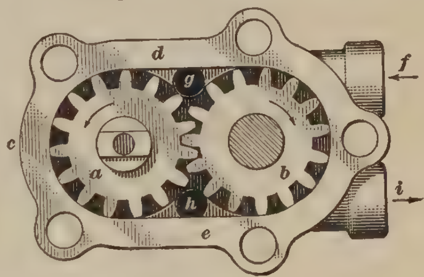


FIG. 8

25. A **sliding-vane pump** operates on the same principle as the gear-pump, but instead of gear-teeth being the means of carrying the oil from the pump inlet to the outlet, the sliding-vane pump utilizes flat metal wings, or *vanes*, which are kept in contact with the walls of the oil chamber by a spring.

A pump of this type is employed in the lubrication system of the Dodge Brothers car, being shown at *d*, Fig. 3 (*a*) and (*b*). The construction of this pump is shown in Fig. 9; (*a*) is a top view of the entire assembly, while (*b*) and (*c*) show, in perspective, the construction of the rotating members. The three views should be referred to in reading the description.

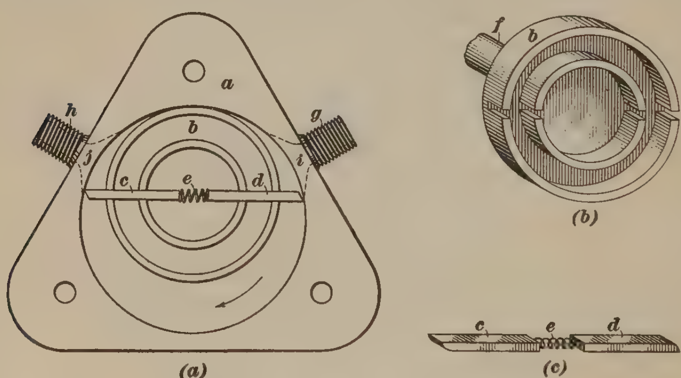


Fig. 9

The pump is composed of a casing *a*, a rotating piston *b*, and two vanes *c* and *d*, with a spring *e* between them. The piston *b* is rotated by a shaft *f*, which is driven by helical gears from the front end of the engine crank-shaft; the piston *b* is located eccentrically in a circular machined chamber of the pump casing, as shown. The oil coming from the suction pipe enters the pump through the connection *g* and passes into the main supply pipe by way of the connection *h*. An inlet port *i* and an outlet port *j* are cut in the wall of the circular chamber as indicated by the dotted lines. The two vanes *c* and *d* are free to slide in a slot machined across the piston. The spring *e* presses the two vanes outward so as to keep the outer edges

of the vanes against the wall of the circular chamber as the piston rotates.

The action of the pump depends on the motion of the vanes in the circular chamber of the casing. Suppose that the piston *b* is in the position shown at view (*a*), and that it starts to rotate in the direction of the arrow. As soon as the vane *c* has covered the lower edge of the intake port *i*, it drives the oil in the crescent-shaped space between the piston *b* and casing *a* before it and out through the outlet port *j*. In the meantime, as soon as the vane *c* has covered the lower edge of the inlet port *i*, oil is drawn through this port into the space behind the vane *c* until it has nearly reached the position of the vane *d*. As soon as the vane *d* passes the lower edge of the port *i*, it drives oil before it and draws oil behind it; the two blades, or vanes, thus alternate in driving the oil before them, thereby producing an almost continuous flow of oil.

If for any reason the oil pump is disassembled, be sure that the key which fits in the oil pump drive shaft and piston *b* is reinserted properly, that the coiled spring *e* is in place, and that the vanes *c* and *d* are so placed in the piston that their flat faces are in the direction of rotation of the piston.

26. In **plunger force pumps,** some rotating part of the engine through an eccentric or a cam actuates a plunger fitting closely in a barrel or chamber, and moving to and fro. Oil flows into the barrel on the outward motion of the plunger and is discharged on the inward motion.

A pump of this type is used on some models of the Haynes "Light Six" engine, and is illustrated in section in Fig. 10. The pump is exaggerated in relation to the crank-case, which is shown diagrammatically, in order to make the details of construction more clear. The pump consists of a horizontal cylinder *a* bored to fit closely the plunger *b*, which is pushed inwards by an eccentric *c* on the cam-shaft *d*, and outwards by a compression spring *e*. A ball check-valve *f* is placed on the suction side of the pump, and a similar check-valve *g* on the delivery side.

The action of the pump is as follows: On the outward stroke of the piston, the check-valve *g* is closed and a partial vacuum

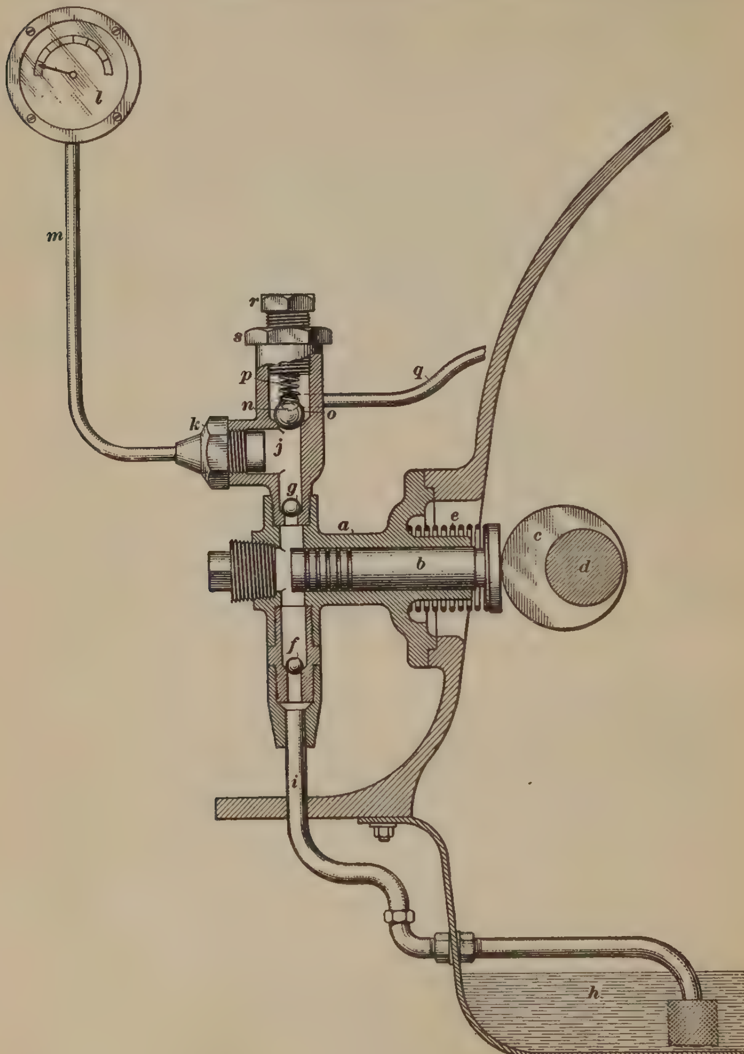


Fig. 10

is formed in the pump cylinder. In consequence, the atmospheric pressure on the oil in the reservoir *h* forces oil up the

suction pipe *i* which joins the oil reservoir and the suction side of the pump cylinder; the oil lifts the suction check-valve *f* and fills the pump cylinder. The operation just described is generally referred to as the suction of the oil from the reservoir to the pump chamber. On the next, or inward, stroke of the pump plunger, the suction valve *f* is closed by the pressure of the oil on it, and the oil in the pump chamber lifts the delivery check-valve *g* and passes out into the chamber *j*. A connection *k* leads from the chamber *j*, and is connected to the oil-pressure gauge *l* by the pipe *m*. The outlet *n*, indicated by the dotted circle, is above the pressure-regulating valve *o*, and the pressure required to raise the ball *o* against the pressure of the spring *p* is registered on the gauge *l*. The oil that passes the valve *o* leaves the pump by way of the outlet *n*, and is carried by the pipe *q* to the bearings of the engine.

27. In **lifting pumps,** oil flows into the barrel on the outward stroke of a piston, and is also discharged on the same stroke; on the inward stroke, oil passes from one side of the piston to the other through a valve in the piston itself.

A lifting pump is employed in the engine of the Reo car, and one type used in this car is shown in cross-section in Fig. 11. The pump is located in the oil reservoir of the crank-case and the bottom is enclosed by a filter screen through which all oil entering the pump must pass. The pump consists of a body *a* in which a cylindrical bucket *b* moves up and down. This bucket is fitted at its lower end with an upwardly opening ball check-valve *c*, which is prevented from being raised out of the bucket *b* with the oil by the cross-pin *d*. An upwardly opening ball check-valve *e* is also placed at the bottom of the pump body *a*, its upward motion being limited by the

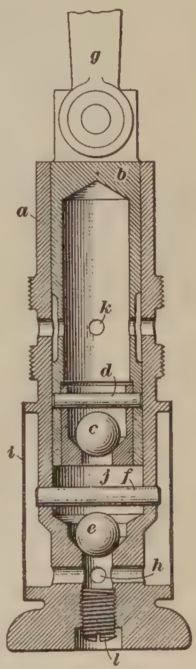


FIG. 11

cross-pin *f*. The pump bucket is driven through the connecting-rod *g* from an eccentric on the cam-shaft. On the upward stroke of the bucket *b*, the check-valve *c* is seated, but the check-valve *e* is open and oil is drawn in through the inlet *h* and wire mesh *i* to the pump chamber *j*. As soon as the downward stroke of the bucket begins, the suction check-valve *e* is seated by the pressure of the oil above it and the delivery check-valve *c* opens, so that the oil in the pump chamber can pass to the inside of the plunger. On the next upward stroke, the oil is lifted by the bucket *b* and forced out of the outlet *k*, whence it passes to the crank-shaft main bearings and timing gears. The plug *l* can be unscrewed to drain the pump.

28. When the oil pump is located directly in the oil reservoir in the bottom of the lower crank-case, the opening into the pump is submerged in oil at all times as long as there is any oil in the reservoir, and this insures a prompt action of the pump as soon as the engine starts. If the pump is located some distance above the oil reservoir, the oil may leak out of the suction pipe; it then becomes necessary to *prime* the pump in order to make it pump oil; that is, the pump and suction pipe must be filled with oil by hand. Special attention must be given to the pump after it has been removed and replaced, or all of the oil has been washed out of the oil reservoir. Should the oil-pressure gauge fail to register after new oil has been poured into the oil reservoir, the oil line should be disconnected at some point above the pump and a liberal quantity of oil pured into the pump. In case a ball check-valve is located in the line in such a position that the oil cannot pass to the pump, the ball can be removed by the magnetized tang of a file, or by a magnet and a wire nail. The nail is placed against the magnet and then contact is made with the ball and spring, and the ball can be lifted out.

OIL REGULATORS

29. Oil pumps used in the lubrication systems of automobile engines are often so constructed that the quantity of oil delivered by the pump may be varied. When a circulating

constant-level splash system is employed, there is no need for an adjustable oil pump, because the depth of the oil in the splash troughs is limited, and all excess drains back into the oil reservoir. Provision is generally made in this system, however, for the limiting of the maximum pressure that can be developed in the oil line. A regulator used for this purpose is known as an *oil relief valve*. This valve serves as a safety valve and prevents the breaking of any part of the system in case the oil delivery pipes should get blocked up in some manner.

A relief valve which limits the maximum oil pressure in the lubrication system is shown in cross-section in Fig. 12. It is located at some point in the system on the discharge side of the oil pump. The oil from the pump enters the body *a* of the relief valve through the pipe *b*, and is discharged through the outlet *c*. An opening *d* communicates with the suction side of the pump, and is normally closed by a ball valve *e*, which is held to its seat by a helical spring *f*. The tension of the spring can be changed by means of the adjusting screw *g*, which can be locked by the locknut *h*. The pressure at which the ball valve raises depends on the tension of the spring *f*.

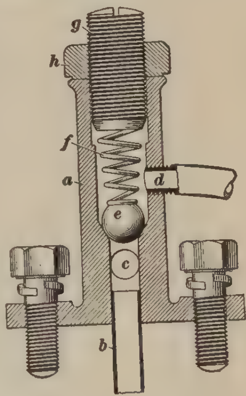


Fig. 12

Screwing in the adjusting screw *g* increases the pressure in the lubrication system, and screwing it out lowers the pressure. As soon as the pressure in the oil delivery pipe *b* reaches that for which the relief valve is set, the ball is lifted off its seat and oil passes through the outlet *d* and back to the suction side of the pump, sometimes directly to the oil reservoir.

30. A device of this kind as sometimes constructed does not regulate the pressure of the oil passing through the lubrication system, but simply shows whether or not the system is working properly. Such a regulator is shown in Fig. 10 in connection with the pump used on the Haynes "Light Six"

engine. As shown in the illustration, all of the oil which goes through the discharge pipe must pass to the outlet *n* by way of the port controlled by the ball check-valve *o*, and no oil will pass through the system until the pressure of the oil is sufficient to raise the ball from its seat. This pressure, which is registered by the gauge *l*, can be varied by changing the pressure of the spring *p* upon the ball *o*. Screwing the adjusting screw *r* right-handed, or in, increases the pressure in the system, and screwing it left-handed, or out, decreases the pressure. The final adjustment is fixed by means of the locknut *s*. Changing this adjustment will in no way change the quantity of oil delivered by the pump.

The pressure of the oil is properly adjusted at the factory, and the original setting of an oil regulator should be changed only under extreme conditions, as, for instance, when the entire system has been dismantled and overhauled. Information on the correct pressure should be obtained from the makers, or from the agents of the factory in the locality where the work is being done, as it is very important that the adjustment be made correctly.

31. When plunger pumps are used in the lubrication system, the usual way of varying the oil delivery is to change the length of the stroke of the plunger, by means of the adjustment provided for that purpose. An investigation of the pump apparatus should readily reveal this adjustment and whatever changes are made should be done advisedly, as the correct adjustment is made at the factory, and there is little necessity for change under ordinary conditions.

32. Vacuum Regulators.—With the oil-regulating devices so far described, the quantity of oil delivered to the lubricating system will be approximately in proportion to the speed of the engine, and no provision is made for maintaining the oil pressure in conformity with the engine load. The result is that when the adjustment is properly made for full load, there will be an excess of oil when the engine is idling or running under light load with the throttle nearly closed. During the suction stroke, with the throttle in its nearly closed posi-

tion, the vacuum in the engine cylinder is at its maximum, and there is a tendency for the oil to be drawn into the combustion chamber, with the attendant evils already described. Experiments made with a view of having the lubrication controlled by the throttle valve have proved more or less unsatisfactory, because of the fact that the throttle opening does not vary proportionately with the engine load. It was found, however, that the oil pressure, and likewise the quantity of oil delivered to the bearings, could be regulated to conform to the engine load by a suitable pressure release or by-pass in the oil line, controlled and operated by the pressure in the intake manifold. Some of the lubrication systems are now controlled in this manner and the method of control is known as *vacuum oil regulation*. This method of regulating the oil supply is employed in the Marmon lubricating system described in Art. **19** and illustrated in Fig. 4, the pipe leading to the intake manifold being shown at *z*. The construction of the regulator *n* is shown more clearly in the view of Fig. 13.

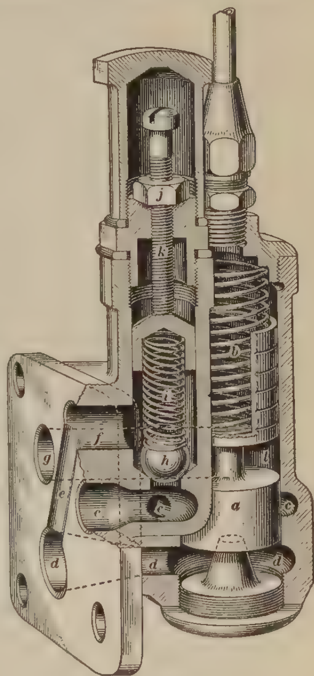


FIG. 13

Briefly, the action of the regulator is as follows: When the engine is idling the carbureter throttle valve is almost entirely closed, and there is a nearly perfect vacuum in the intake manifold. This vacuum causes the piston *a*, Fig. 13, to be raised against the pressure of the coil spring *b*, allowing the oil to flow without any resistance except the eddying resistance in the oil lines. The pressure of the oil in this case is not very great, depending largely on the body of the oil. The oil enters the regulator at *c*, flows through outlet *d*, and by-pass

e, and thence from opening *f* to the oil line leading to the overhead valve mechanism, as already described. As soon as the throttle valve of the carbureter is opened suddenly, the vacuum in the intake manifold is released, and the pull on the vacuum valve plunger *a* is decreased to such an extent that the spring *b* on its top plunges it to the bottom of the cylinder. The passage between inlet *c* and outlet *d* is then closed by the piston *a*, and the oil is forced to pass through the passage controlled by the check-valve *h*, whence it passes through the remainder of the lubricating system by way of the passage *f*. Passage *g* is placed directly opposite the undercut in the piston *a*, that is, the space *l* between the upper and lower members of the piston, when the piston is in its closed position. Its purpose is to allow for the exhaust of any oil that might have accumulated in the compartment *l* by having been drawn past the piston during the suction period of the line to the intake manifold.

The amount of pressure received by the oil at full throttle opening is determined by the tension of the valve closing spring *i*. This tension is set at the factory, and should not be changed unless absolutely necessary. In case any adjustment is necessary it can be made by backing off the locknut *j* and raising or lowering the adjusting screw *k*. Lowering this screw increases the pressure, and vice versa. When the correct adjustment is obtained the adjusting screw should be locked in place by the locknut

OIL STRAINERS

33. Practically all automobile lubrication systems are fitted with a fine-mesh wire strainer on the intake side of the pump. The purpose of this strainer is to remove metal particles worn off the rubbing surfaces, carbon, and similar foreign substances from the oil, before it is delivered to the splash troughs or bearings. Oil strainers are made in different ways, but, as a general rule, they are easily removable for inspection, cleaning, or replacement. One way in which this may be accomplished is illustrated in Fig. 3, which shows the oil strainer used in the lubrication system of the Dodge Brothers

engine. The strainer *b* is attached at one end to a removable flange through which it is connected to the suction pipe *c* of the oil pump. Consequently, the strainer *b* can be removed easily for cleaning by disconnecting the suction pipe, removing the two capscrews which hold the flange in place, and draining the oil from the oil reservoir.

Sometimes the oil strainer forms a part of the oil pump, as is the case in the Reo lubrication system, the pump of which is illustrated in Fig. 11, and the strainer is exposed by removing the pump.

To insure that only clean oil can enter the oil reservoir of the engine-lubrication system, as a rule, an oil strainer of fine-mesh wire gauze is placed in the filler opening of the oil reservoir, which opening in many cases also serves as the crank-case breather pipe.

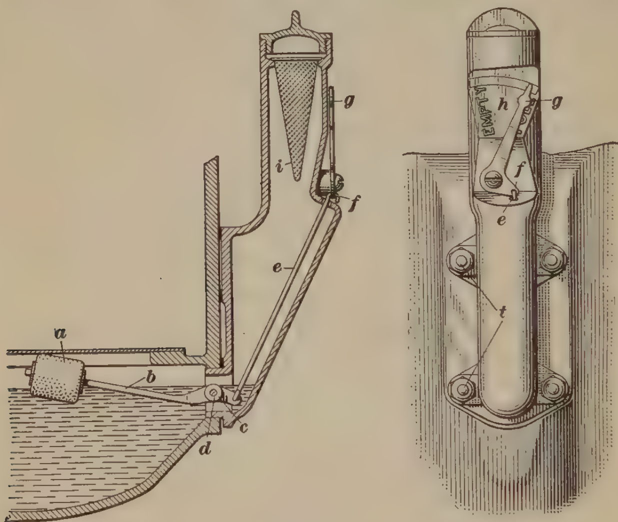
OIL-LEVEL GAUGES

34. For the purpose of showing the height of the oil in the oil reservoir of automobile engines, oil-level indicators are usually fitted. There are, in general, three types of such indicators, which are gauge cocks, float oil gauges, and removable-rod gauges.

35. **Gauge cocks** are usually two in number and are screwed into the oil reservoir at different heights. An example of this method of finding the oil level is given in Fig. 1, where gauge cocks are shown at *e* and *f*. The oil should be poured into the oil reservoir until it runs out of the upper cock, when the cock is open, and should not be permitted to drop below the level of the lower cock. As the outer openings of these cocks are exposed, they soon become clogged up with road dirt and oil, and it is necessary to clean them out with a wire in ascertaining the oil level by their use.

36. A **float oil-level gauge** is most commonly used. It consists of a cork, or hollow metal float, that floats on the surface of the oil in the reservoir, and by means of a vertical rod, or suitable connecting links, indicates the height of the oil in the reservoir at a point which can be easily observed by

the operator. In some cases, the observer must judge from the position of the top of the rod, the level of the oil in the reservoir; while, in others, the level is indicated on a graduated gauge. In the engine shown in Fig. 3, a hollow metal float *q* has attached to it a vertical rod *r*, and the height of the oil in the reservoir is indicated by the position of the button *s* on the upper end of the wire rod. A similar method is employed in the systems shown in Figs. 4 and 6, but in these engines the upper end of the rod extends into a small case with a glass



(a) FIG. 14 (b)

cover at the front. The glass is provided with graduations, and the exact height of the oil in the reservoir is revealed by a glance of the observer.

37. The method of indicating the level of the oil in the reservoir by means of a float and connecting links is shown in Fig. 14 (*a*) and (*b*), which illustrates the method used in the engine of the Reo automobile. In this case, the cork float *a* has attached to it a rod *b*, the rod being fastened at the other end to the bell-crank *c*. Crank *c* is pivoted at *d*, and a link *e* is connected at one end to the free arm of the crank *c*, and at

the other end to an arm of the bell-crank *f*. The other arm of the bell-crank *f* forms an indicator pointer *g*, which registers the level of the oil in the oil reservoir. When the float *a* drops, the link *e* is raised and the indicator *g* is moved back toward the "empty" position on the oil gauge *h*, and when new oil is added, the float rises, the link *e* is pulled downwards, and the pointer *g* is moved toward the "full" position. The height of the oil can be noted at any time by observing the position of the indicator hand *g* in relation to either extreme position. In case the oil gauge does not register correctly, the float assembly should be removed by taking off the nuts *t*, and bending the rod *b* until the correct indication is obtained. The oil screen through which the new oil is filtered is shown at *i*. A method similar to this is employed in the Grant engine-lubrication system shown in Fig. 7. In the Grant engine, a gauge *z* with a graduated dial is used to indicate the oil level.

38. A **removable-rod gauge** consists simply of a flat rod which extends through a tube at the side of the crank-case into the oil in the oil reservoir. When it is necessary to ascertain the level of the oil in the reservoir, the rod is pulled out of its enclosing tube, and the oil on the rod will show the extent to which the rod has been submerged in the oil. Two notches are cut into the rod, one at the point of the lowest safe oil level, and the other at the highest level, and enough oil should be kept in the crank-case so as to register between the two notches. A gauge of this type is employed in the FB model of the Chevrolet automobile, and others.

OIL-PRESSURE GAUGES

39. The oil-pressure gauge located on the instrument board of an automobile in plain view of the driver, is intended as a guide to the performance of the oiling system. While this gauge does not necessarily indicate the amount of oil that is circulating through the lubrication system, it registers the pressure, and, therefore, keeps the driver informed on what is taking place in the system. Pressure gauges register different pressures according to the car on which they are used, and the

driver should know what the correct pressure should be at the different engine speeds in any particular car, in order that he may detect immediately any irregularity in the operation of the system. The variation in this pressure in different cars is sometimes great, as, for instance, in a Dodge Brothers car the gauge reading should be about 2 pounds at 25 miles per hour, while in a Marmon car, the gauge should register from 25 to 30 pounds at the same speed. The pressure in a system varies according to the speed of the engine, the temperature, and thickness of the oil. When the engine is cold, or when new oil is poured into the oil reservoir, the gauge should register a slightly higher pressure than when the engine is hot, or when the oil has become thinned by use. The longer the oil is used, the thinner it becomes, and, as before suggested, the decrease of the pressure at the gauge serves as an indication of the condition of the oil.

The adjustment of the oil-pressure regulator is made at the factory, and under ordinary conditions, there is very little likelihood of any change being necessary after the car has been placed in service. If the occasion requires, however, the change should be made only when the engine is hot. If for any reason, there is a sudden deviation from the customary pressure registered by the gauge when the engine is running, the engine should be stopped, and the cause located and removed, as otherwise serious damage to the engine will probably result. If, after the crank-case has been emptied and cleaned and a new supply of oil has been put into the oil reservoirs, no pressure is registered by the oil gauge, the pump should be primed, as the trouble is probably due to the inaction of the pump. If still no pressure is registered the entire pipe system should be examined for possible clogging. If this does not reveal the cause of the stoppage, the pipe leading to the gauge should be disconnected to see if the oil is circulating up to this point. If so, the trouble is located in the gauge, and it should be returned to the service station for repair or replacement. Other causes of no pressure indication on the gauge are dirt under the check-valves of plunger pumps, or air leaks in the suction pipe.

In case the oil-pressure gauge shows full pressure when running at a low speed, unless the engine has just been started on a cold day and the oil is congealed, some foreign matter has become lodged at some point in the pump outlet pipe. As the gauge shows pressure, it is evident that the stoppage is not located at any point between the gauge connection and the oil pump, and the trouble should be sought on the side of the gauge connection away from the pump. The pipe should be removed and the obstacle forced out, either by running a wire through the pipe, or by blowing it out by compressed air. It is a good plan to disconnect the supply pipe from the pump occasionally, and blow through it with compressed air, even though no stoppage is indicated.

MISCELLANEOUS LUBRICATION SUGGESTIONS

40. Too Much Oil in Cylinders.—Too much oil in the cylinders is indicated by white smoke in the exhaust and fouled spark plugs and valves. The accumulation of oil on the spark plugs causes misfiring by short-circuiting the contact points. If the oil supply is not cut down promptly, there will soon be an accumulation of carbon on the piston and cylinder walls, as well as in the piston-ring grooves.

Trouble from this cause, unless entirely too much oil has been poured into the crank-case, is rarely experienced with circulating constant-level splash oiling systems, in which no means are provided for adjusting the oil level. If trouble should occur, however, the advice of the maker of the engine should be sought. In splash oiling systems in which the flywheel of the engine circulates the oil, pouring too much oil into the crank-case will give excessive cylinder lubrication. The remedy is to draw off oil until the correct level is again reached. In pressure-feed oiling systems of the high-pressure type, the relief valve of the oil pump may be set for too high a pressure, the remedy being to readjust the relief valve for a lower pressure.

41. The amount of oil which gets past the piston into the combustion chamber can be diminished to some extent by the

use of a special oil ring as shown in Fig. 15. This ring has a slanting slot *a* and is installed in its groove in the piston with the slotted opening toward the bottom of the piston. The sharp edge of the slot scrapes the oil from the cylinder wall during the downward stroke of the piston. Many modifications of the oil ring shown are on the market, and one such ring is usually recommended for each cylinder.

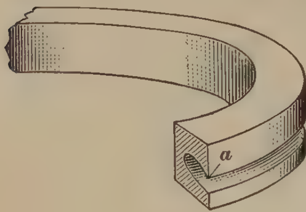


Fig. 15

42. Oil leakage past the cylinders may be also overcome somewhat, by cutting or filing away part of the lower wall of one or both of the lower grooves of the piston, as shown at *a* and *b*, Fig. 16, and drilling small holes *c* about $\frac{1}{32}$ inch to $\frac{1}{16}$ inch in diameter at regular intervals around the groove and slanting downwards about 45 degrees, as shown at *d*. The larger the holes and the greater the number of them the more effectively will the oil be collected, and returned through the holes to the crank-case. It is best to begin with one groove and a few small holes and increase the number each time the engine is overhauled until the over-lubrication trouble disappears. A good way to file this groove is to use a piece of wood 2 or 3 inches in width and of a right thickness to fit snugly in the groove so it will not slip as the file is rubbed against it; then with this as a guide use the edge of the file to make the notch as shown at *a* and *b*, the notch being made about equal in depth all the way around the piston. This notch should not be more than one-fourth of the depth of the groove in which the piston ring fits.

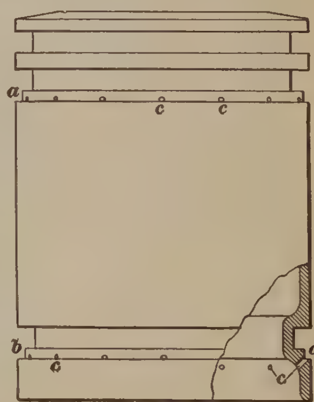


Fig. 16

43. Lack of Cylinder Oil.—If the oil is cut off from the engine either from the supply in the oil reservoir having become exhausted, or from failure of the lubrication system to deliver the oil properly, the engine must be stopped immediately to prevent serious damage to its parts. The first indication of a lack of oil is a sudden sluggish action of the engine with a material falling off in power. Unless the engine is stopped and examined for the cause of the trouble, and oil supplied to the oil reservoir and to the cylinder walls through the spark-plug openings, there will be further symptoms in the shape of dry wheezy sounds, and smoking from openings in the crank-case or base of the engine. If the cause of the trouble is not determined and remedied, the babbitt will be melted out of the bearings, which will be manifested by a terrific hammering and rattling of the engine. It is extremely dangerous to run the engine after this stage has developed. There have been cases where automobiles were run with burned-out bearings in the hope of reaching the nearest repair shop, with the result that one or more connecting-rods were twisted off at the crank end, the crank-shaft scored or warped to such an extent that it was necessary to install a new one, and holes were broken into the crank-case. The expense of having the car towed in would have been slight compared to the cost of making the necessary repairs.

The result of the lack of oil in the cylinders is the scoring of the piston and cylinder wall, and the loss of spring in the piston rings, usually requiring reboring of the cylinders and the renewal of the pistons and rings.

44. Cleaning Oiling System.—Although automobile instruction books frequently make sweeping statements that the crank-case and lubrication system should be flushed thoroughly with kerosene, after draining out the old oil, considerable discretion must be observed in following such instructions. With most plain splash-lubrication systems, the oil system can be safely flushed with kerosene, but in using it, the method of procedure should be about as follows: After the old oil has been drained from the engine, and kerosene

has been poured into the reservoir and the oil troughs filled, the spark plugs should be removed or the priming cocks opened, and the engine turned over rapidly with the hand crank, so as to splash the kerosene up into the cylinders and onto the sides of the crank-case. The engine is then allowed to stand long enough to allow the oil to drain from the cylinder surfaces, after which the crank-shaft should be turned slowly to drive as much as possible of the kerosene from the splash troughs without splashing it into the cylinders again. The drain plug should then be removed from the bottom of the crank-case, or the handy drain control at the side of the engine turned, so as to allow all of the kerosene to drain from the oil sump, the oil drain closed again, and the reservoir refilled with the proper grade of clean cylinder oil. A little oil should be squirted into the combustion chamber through the spark-plug opening, and the crank-shaft turned over rapidly by hand to lubricate all bearing surfaces so that there will be sufficient lubrication on these parts until the oil has had a chance to reach them through the regular channels.

Gasoline should not be used for cleaning out the old oil, as it leaves the parts perfectly dry. Kerosene, on the other hand, will leave a slight coating which will tend to keep the parts lubricated until the fresh oil works into the bearings.

45. Ford engines equipped with electric starting and lighting systems should not have the lubricating system flushed with kerosene when the engine is running. If kerosene is used on these models, it will work through the bearings of the generator and probably cause serious damage to the generator.

It is a bad practice to use kerosene to clean out pressure-lubrication systems, or combination systems in which oil is supplied to some of the bearings under pressure. The kerosene will circulate through the entire oiling system, displacing the lubricating oil, and as it is impossible to drain this oil from the system, a large part will be left to be mixed with the fresh oil when it is put into the crank-case, thus diluting the new oil from the time that it is placed in the engine.

46. As the present-day gasoline contains a large percentage of kerosene, which is not burned in the combustion chamber, the oil in the reservoir becomes in time thinned by the kerosene, and practically all residue in the oiling system is washed into the oil sump. After the old oil is drained out, it is a good plan to flush the engine with a quart or so of a standard cylinder oil; draining the oil reservoir will remove the dirt that has been washed into the reservoir, and, at the same time, will leave the crank-shaft and oiling system full of good clean oil.

When the oiling system has been dismantled, all parts should be cleaned thoroughly with kerosene, and all the oil pipes should be washed out by running the kerosene through them.

47. Use For Old Cylinder Oil.—Old cylinder oil that has been drained from an automobile engine should not be used again in the engine. While it no doubt contains a certain percentage of good oil, it also contains so many contaminating foreign substances as to render its use inadvisable. This old oil makes an excellent lubricant and preservative for anti-skid chains. The chains should be soaked in it long enough to become thoroughly covered with the oil, and then should be hung up to drain.

48. Lubrication of Engine Not in Service.—The improper starting of an automobile engine which has been idle for a couple of weeks or more might result in scored cylinders. The film of oil on both the piston and cylinder walls is practically destroyed as far as its function as a lubricant is concerned, and the piston might travel up and down in a cylinder several hundred times before a new film of lubrication is formed. In an effort to eliminate this, every such engine should have the piston head and combustion chamber flooded with oil so that there will be sufficient lubrication on the cylinder walls and piston when the engine is started. When the oil has been in the combustion chamber long enough to supply the necessary lubrication, the excess should be drawn out by an oil gun, or if the gun is not available, the spark plugs should be left out when the engine is turned over, so as to

insure against too much oil being in the combustion chamber on the compression stroke of the engine. Oil, unlike air, is not compressible and will, if in such a quantity as to fill the combustion chamber, damage either the piston or the cylinder-head gasket as the piston approaches the upward end of its compression stroke.

49. Changing Oil.—When it becomes necessary to change the lubricating oil in an engine from one brand to another, all the old oil should be drawn off and the oil reservoir filled with the new brand of oil. This practice is advisable, as the mixture of two different oils gives a resulting lubricant which is frequently very unsatisfactory.

AUTOMOBILE TIRES
(PART 1)

TIRE CONSTRUCTION AND APPLICATION

TYPES OF TIRES AND RIMS

PNEUMATIC TIRES

1. Introduction.—As the name implies, the **pneumatic tire** consists of a hollow combination rubber-and-fabric exterior filled with air under pressure. It is particularly adapted to the pleasure automobile because of its resiliency, which enables it to absorb the shocks caused by the unevenness of the road surface. No material has as yet been discovered that will satisfactorily take the place of the rubber tire containing compressed air, and hence practically all pleasure cars are equipped with pneumatic tires. **Solid tires,** made of rubber and solid in structure, are used on motor buggies and on nearly all commercial vehicles, where ease of riding is not of prime importance. Another form of tire, known as the **cushion tire,** has been used to a limited extent. It is made of fairly soft rubber in a variety of shapes intended to give a cushion effect.

Pneumatic tires are divided into two subclasses; namely, *single-tube tires* and *double-tube tires*.

2. Single-Tube Tires.—Single-tube tires resemble an endless ring of ordinary rubber hose, the inside being filled with air under pressure. While widely used on automobile wheels in

the early days of the automobile industry, their inherent defects have caused a gradual passing away, until single-tube tires are not used on modern automobiles.

A cross-section of a single-tube pneumatic tire in place on the wheel rim is shown in Fig. 1. The tire *a* is made up of several layers, or plies, of cotton or linen fabric of very open weave embedded in the rubber. The latter forms the air-tight, waterproof portion, and, externally, the wearing surface of the tire. The fabric is shown in four concentric dotted circles in the figure. For mechanically fastening the tire to the wheel rim *b*, a number of *tire lugs* *c* are provided. These lugs project through the wheel rim and are tapped to receive a lug screw *d*, which holds in place a clamp *e* that bears against the wheel rim and holds the tire in place.

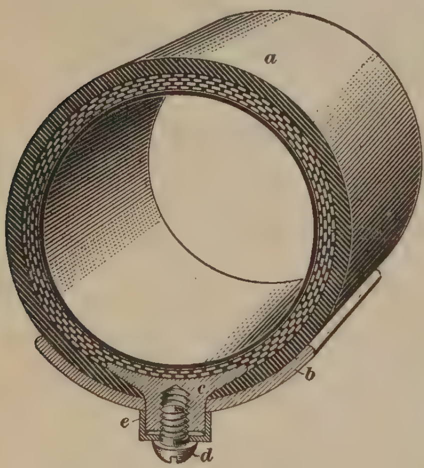


FIG. 1

Instead of using the method of fastening just described, some makers of single-tube tires use studs that are permanently fastened to the lugs; these are then wholly inside the tire, and the tire is fastened to the rim by means of clamps and nuts attached to the studs. Single-tube tires thus attached are intended for use on wire wheels, and cannot be readily used on artillery wheels. Single-tube tires made to be attached as shown in Fig. 1 can be applied to either wire wheels or artillery wheels, provided screws of sufficient length are used.

Single-tube tires are made with either five or eight tire lugs.

3. Classification of Double-Tube Tires.—The form of pneumatic tire that is commonly used on pleasure cars is the

double-tube tire. This tire consists of two parts; namely, an outer part composed of rubber and fabric, and called a *casing*, or *shoe*, and an inner part in the form of a hollow cylindrical ring made of soft rubber, and called an *inner tube*, or simply a *tube*.

Double-tube pneumatic tires may be divided into three types in accordance with the manner in which they are fastened to the rim of the wheel. Thus classified, the three types are the *regular clincher tire*, the *mechanically fastened tire*, and the *quick-detachable tire*.

4. Regular clincher tires are tires that are fastened to a one-piece rim chiefly by the pressure of the contained air, sometimes aided by a few special clamps.

Mechanically fastened tires are tires that are held to the rim by mechanical means.

Quick-detachable tires are tires that are held in place by specially constructed rims and are put on or removed by first removing the detachable portion of the rim. They are made in two forms; namely, the *quick-detachable clincher tire* and the *quick-detachable straight-side tire*, also known as the *Dunlop tire*.

5. Regular Clincher Tires.—The oldest form of double-tube tire is the **regular clincher type**, which is made to fit one-piece clincher rims. The tire is held in place chiefly by *beads* that fit snugly in place under the *clincher*, or *bent-up portion*, of the rim. The beads on a regular clincher tire are soft; that is, they are made of rubber and fabric only, so as to be flexible enough to slip over the rim flange. On the larger tires of this type, tire lugs, or clamps, are used to aid in holding the tire on the rim.

6. In Fig. 2 is shown a short section of a double-tube pneumatic tire of the regular clincher type in place on the wheel rim. The casing, or shoe, *a* of the tire, instead of being completely tubular, is open along the side next to the rim *b*. The middle of the rim is nearly flat and the edges are curved inwards toward each other, as at *c*, so as to form a clinch on each side for holding the tire casing in place. The casing is formed with beads *d* that fit into the clinches of the rim. An inner

tube *e* of soft elastic rubber is placed inside the casing. This inner tube retains the air in the tire. It is provided with a valve through which air can be forced into the tube by means of a pump or some other device, and the valve can be opened to allow the escape of air from the tube when it is to be deflated. This air valve is not shown in Fig. 2. The pressure of the compressed air forces the beads of the casing into the clinches of the rim and retains them there so that the tire is held in place when fully inflated.

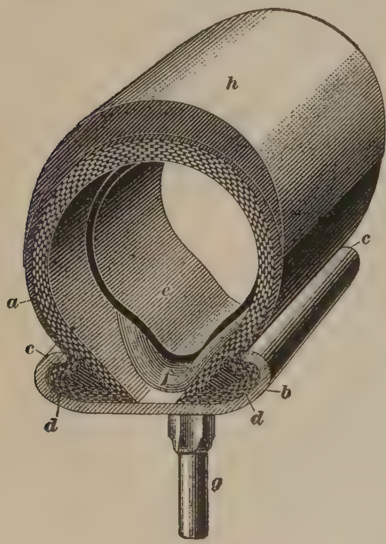


Fig. 2

In order to secure the tire more firmly to the rim, that is, so that it will not be thrown out when a side pressure is exerted upon it, as when a car is turning a curve at high speed, devices variously called *tire lugs*, *clamps*, *clips*, or *security bolts*, of which the head of one is partly shown at *f*, are provided. The head *f* of the tire lug is shaped to conform to that part of the casing with which it is in contact. A bolt extends from the head of the lug inwards toward the center of the wheel, and is threaded to receive a nut *g*, which is used to draw the head of the clamp down tight against the inside of the casing. In the smaller tire sizes in which the regular clincher tire is usually made, tire lugs are generally dispensed with and the bead alone is depended on to hold the tire in place.

The thickest portion *h* of the tire is called the *tread*. It is the part that comes in contact with the roadway when the tire is in use. One or two strips of fabric, called *breaker strips*, are generally placed between the tread and the main portion of the fabric. These strips strengthen the casing, and in case of great wear become exposed and thus indicate the necessity of repair.

When an ordinary clincher tire of the form just described is being placed upon the wheel rim or removed from it, the beads of the tire must be lifted over the clincher portion of the rim. The outside diameter of the clinch is larger, of course, than the inside diameter of the bead of the casing. The bead must therefore be elastic enough to stretch sufficiently to pass over the clinch. In the tire shown in Fig. 2, each bead has a rubber filling that is elastic enough to allow the tire to expand as just described.

7. Mechanically Fastened Tires.—The *Fisk bolted-on tire*, a short section of which is shown in Fig. 3, is an example of a mechanically fastened double-tube pneumatic tire. The rim *a* of the wheel is made of a flat strip of steel. The part of the tire casing in contact with the rim is also made flat. Two retaining rings *b*, held in place by means of bolts that extend from side to side through the tire just outside the wheel rim, are provided to hold the tire in place. The head of one of the bolts is shown at *c*, and the nut on it at *d*. The head fits over the side of the wheel rim *a* and retaining ring *b*, and a clamp *e* just under the nut *d* fits the wheel rim and ring on the opposite side. The tire casing is split circumferentially at *f* in a plane perpendicular to the axis of the wheel.

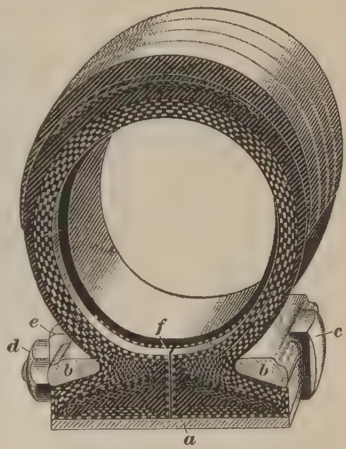


FIG. 3

8. Quick-Detachable Clincher Tires.—The standard form of double-tube tire, which is used much more extensively than the regular soft bead clincher type, is the quick-detachable clincher tire. The only difference between this form of tire and the regular clincher type is in the construction of the bead. In the quick-detachable type, the bead is made stiff and inextensible, and the tire is put on, or removed from, the rim

by removing a detachable ring that forms one of the clinches, instead of by stretching the bead over the edge of the clinch.

9. A short piece of a quick-detachable clincher tire, in place on one form of a Firestone quick-detachable rim, is shown in Fig. 4. The beads *a*, which are much stiffer than in the regular clincher tire, fit into two clinches *b* and *c* that hold the tire in place. The one clinch *b* is an integral part of the rim, but the other clinch *c* is a solid ring that is detachable. The retaining ring *c* can be removed by pressing it in toward the center of the rim after the tire has been deflated, and then removing the split ring *d* from the groove of the wheel rim into which it fits. The split ring can be pried out of the groove by a screwdriver, or similar tool, placed in a notch *e* cut in the side of the wheel rim. The ring *d* is prevented from sliding around the rim by a pin *f* that is attached rigidly to the ring and that fits in a second notch in the rim. After removing the rings *c* and *d*, the complete tire can be slipped off sidewise from the wheel rim. When being removed, the tire should first be taken off at the side opposite the air valve.

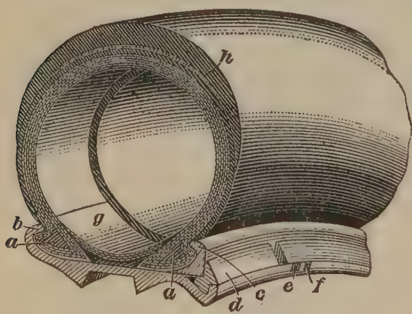


Fig. 4

A loose protective flap *g* in the shape of a channel ring is furnished by some tire makers. This flap is placed between the edges of the casing to form a close joint and a smooth surface for the inner tube to bear against. The flap is generally made of rubber strengthened by embedded woven fabric. A breaker strip *h* is placed on the inside of the tread of the tire to strengthen it. No tire lugs, or clamps, are required for a tire of this type.

10. In connection with quick-detachable clincher tires, it is to be noted that such a tire cannot be applied to a regular one-piece clincher rim. A regular clincher tire can be applied

to a rim designed for a quick-detachable clincher tire of the same size, but it is not advisable to do this because quick-detachable clincher rims are usually not drilled for tire lugs, or security bolts, and hence the tire is liable to be torn off the rim while rounding corners if it is not fully inflated.

11. Quick-Detachable Straight-Side Tires.—One of the first quick-detachable tires to be placed on the market, and one that is quite extensively used, is the *quick-detachable straight-side tire*, or *Dunlop tire*. A section of such a tire mounted on the wheel rim is shown in Fig. 5. This tire is not provided with beads, as are the regular clincher and quick-detachable clincher tires, but is built with straight sides and is held in place by solid retaining rings *a* that conform in shape to the sides of the tire. In order to prevent the inner edges of the straight-side casing from expanding appreciably in diameter when the tire is inflated, endless wires *b* are embedded in the hard-rubber base. These wires form a ring that will not expand, and hence a tire of this kind cannot be put on or removed over a clinch. A quick-detachable straight-side tire is removed in the same manner as a quick-detachable clincher tire.

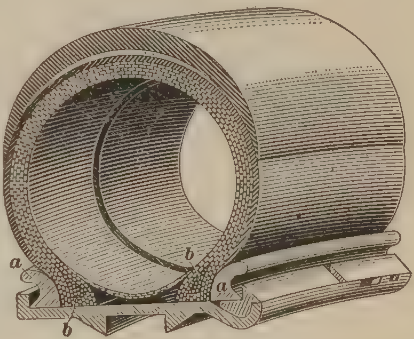


FIG. 5

An ordinary quick-detachable clincher tire can be used on a rim of the type shown in Fig. 5 by simply reversing the rings *a*, thus forming clinches.

12. Detachable-Tread Tire.—In order to provide means for readily replacing the worn tread of a pneumatic tire, a type of tire in which the casing is made up of two distinct and separate parts has been designed. An example of such a tire is the Goodyear *detachable-tread tire*, the two-part casing of which is shown in Fig. 6. This casing is made up of the tread *a* and the car-

cass *b*, which is the fabric portion of the tire. In view (*a*) the tread is shown in place on the carcass, and in view (*b*) it is shown removed.

The detachable tread *a* is of regulation thickness and in addition has two plies of fabric *c* at the base. It is held in place, when assembled, as shown in (*a*), simply by the friction between the two parts resulting from the pressure of the air in the tire. The sides of the tread are provided with two non-stretchable beads *d*, which hold it snugly to the sides of the carcass. Instead of being made exactly round to fit the carcass perfectly, the

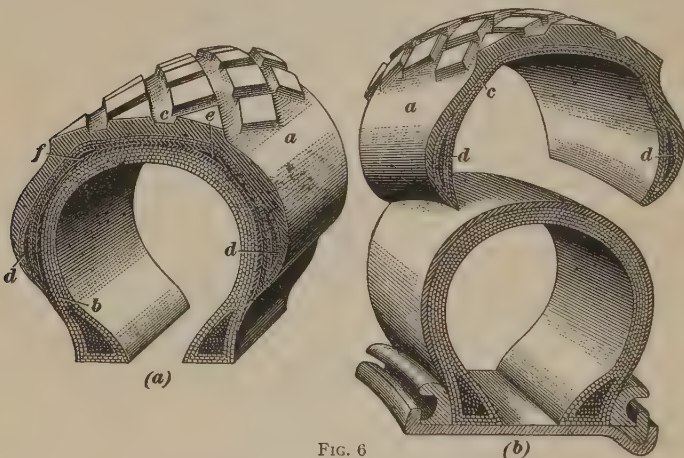


FIG. 6

inside of the tread is made slightly flat on top so as to form two air chambers *e* and *f*, one on each side of the point where the tread comes in contact with the road surface. It has been found from experience that this construction prevents a certain amount of wear that would otherwise be caused by the friction between the two parts.

13. With the detachable-tread tire, if either part becomes worn it can be replaced without buying a complete casing. The carcass is held to the rim in the usual manner; the one shown in Fig. 6 is of the quick-detachable straight-side type.

DEMOUNTABLE AND QUICK-DETACHABLE RIMS

14. Explanation of Terms.—A rim so constructed that it can be easily removed from the wheel, thus affording a ready means for changing tires on the road, is called a *demountable rim.* By having the rim demountable, a complete spare tire can be carried inflated on an extra rim, so that the arduous work of changing the tire on the rim on the road and inflating it is eliminated. If the demountable rim and its fastenings are of proper form and in good condition, they can be quickly removed; an inflated spare tire with its rim can then be substituted in much less time than is ordinarily required for putting on a tire, together with its inner tube, and then inflating it.

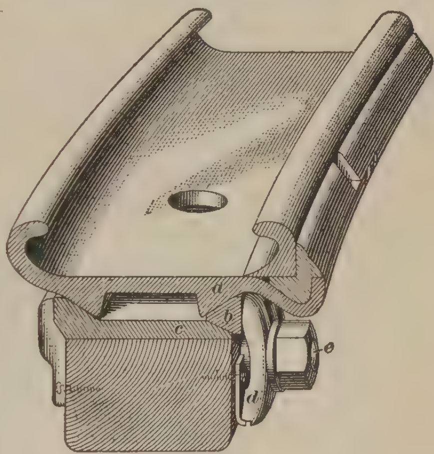


FIG. 7

A *quick-detachable rim* is one that permits the removal of the tire from its rim without the physical effort required to stretch it over a clinch, as in the regular clincher type.

A *quick-detachable demountable rim* is a demountable rim that is fitted with some form of quick-detachable device. With this type of rim, the rim and tire can first be removed from the wheel, after which the tire can readily be removed from the rim by means of the quick-detachable appliance, or the tire can be removed without removing the entire rim.

15. Types of Demountable Rims.—Various methods for securing demountable rims to the felloe of the wheel, so that they can be readily detached, have been devised. A form of demountable rim that is widely used is that shown in Fig. 7, which shows a short section of one form of the Firestone quick-

detachable demountable rim. The rim *a* is held in place by a wedge-shaped clamping ring *b* that fits between the beveled edge of the rim and the beveled edge of the felloe band *c*. This ring, and consequently the rim, can be removed by removing six rim clamps *d*, which are held in place by hexagonal nuts on bolts *e* having specially shaped heads.

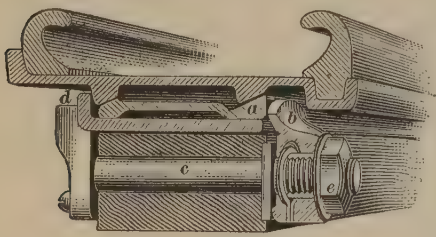


FIG. 8

16. A cross-section of the Stanweld demountable rim number 40, which is similar in principle to the Firestone, is shown in Fig. 8. An adjusting ring *a*, having two beveled surfaces, is held in place by six clamps *b*. The clamp bolts *c* extend through the felloe and butt against the felloe band *d* by means of specially shaped heads. The clamps *b* are supported by the clamp-bolt nuts *e* in such a manner that they are free to adjust themselves to position at all times. The adjusting ring *a* is a band of spring steel and is transversely split. It is easily removed or applied with the hands when the clamps are unlocked.

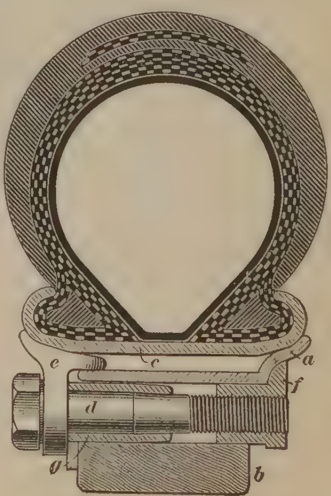


FIG. 9

17. An example of a *bolted-on demountable rim* is shown in Fig. 9, which is a sectional view of the Baker bolted-on rim applied to a tire. A felloe band *a* is shrunk on the wooden felloe *b* of the wheel and the rim *c* is held in place by six bolts *d* that support the same number of wedges *e*. The nuts *f* are fixed in the felloe and the bolts are screwed into them when the rim is assembled. A sleeve *g* forces the wedge *e* out when the bolt

is unscrewed. The sleeve is crimped into a groove in the bolt. The rim *c* has integral clinches like a regular clincher rim, but it is split transversely so that the circumference can be reduced when the tire is put on or taken off. When assembled, the ends of the rim are bound together by means of an anchor plate and four stud bolts.

18. Fig. 10 shows the construction of the Booth demountable rim, which differs from the more common forms previously described in that a special locking device is used. Three of the locking devices are arranged at equal intervals around the channel-shaped wheel rim *a*. By means of these devices, the cleats *b*, which are attached to the demountable rim *c*, may be locked in place on the solid rim *a*, thus holding the demountable rim *c* on the wheel.

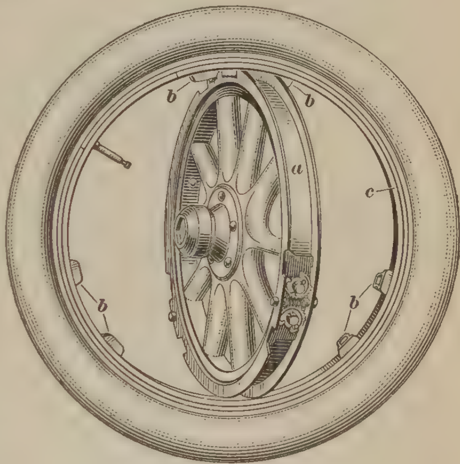
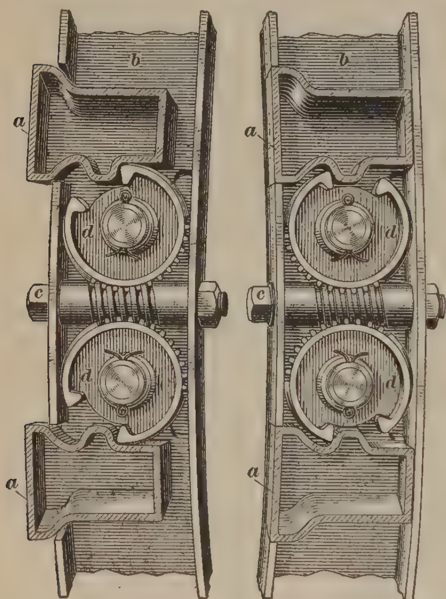


Fig. 10

19. The locking device used on the Booth demountable rim is shown in detail in Fig. 11 in both the unlocked and the locked positions. When in the unlocked position, as shown in view (*a*), the cleats *a* are free to be slid off of the wheel rim *b*, and, therefore, the demountable rim and tire can be removed. The demountable rim is locked in place on the wheel rim *b* by turning a worm-screw *c*, which meshes with two worm-gears *d* that in turn engage with projections on the cleats *a*. Turning the screw *c* in a right-handed direction revolves the gears *d* in such a way as to draw the cleats *a* on the rim *b* and lock the demountable rim in position, as shown in view (*b*). This device, being a worm-and-gear combination, is self-locking.

20. Demountable rims varying somewhat in design from those just described are also used, but the most common types are those that make use of bolts, as shown in Figs. 7, 8, and 9. As a general thing the method of removing a demountable rim is comparatively simple, so that it can usually be ascertained upon a brief examination.

21. Forms of Quick-Detachable Locking Devices. Several forms of quick-detachable mountings for tires are used, each with its distinctive method of removal and replacement. A common form of rim is that in which the inner retaining ring is secured in place by means of a locking ring, as shown in Figs. 4 and 5. In some rims of this type, the locking ring is made with an L-shaped cross-section, but it is applied in the same manner as the one referred to.



(a) FIG. 11 (b)

22. Another common form of quick-detachable rim is that in which a single side ring may be expanded and removed without the use of a locking ring, an example of which is the Stanweld rim shown in Fig. 8. Two detailed views of the locking device used on this rim are shown in Fig. 12. The outer side ring *a* of the rim is split transversely, and on either end is an L-shaped lug *b* that projects through a slot made in the bottom of the groove into which the ring locks. The lock consists of a cam *c* operated by a lever, both being fastened to the rim base *d*. When the side ring is locked, as shown in view (*a*), the wide portions of the cam *c* extend into the slots of both

lugs *b* that are on the ends of the ring. When in the locked position, the cam-lever is held in place by means of a small projection on the lever that catches in a corresponding depression in the rim base.

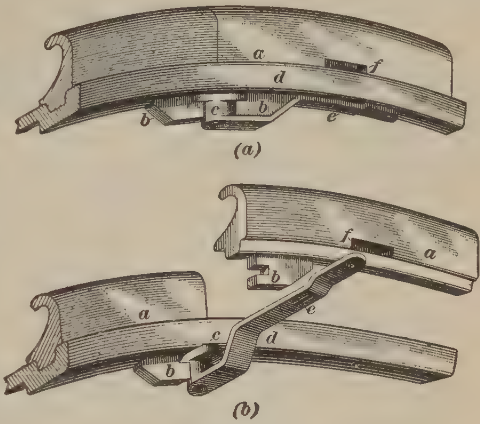


Fig. 12

The lock is disengaged by inserting a screwdriver between the cam-lever and the rim base and swinging the lever out until the cam is released from the lugs, as shown in view (*b*). A slot *e* in the lever allows the screw driver to be easily engaged with it during this operation. The side ring *a* is removed by inserting a screwdriver in a slot *f* and prying the ring off over the edge of the rim, when it can be taken off with the hands.

23. In the Standard Universal rim, a removable side ring like that shown in Fig. 12 is used, but it is held in place by means of a **T** bolt and cap instead of by a special latch as on the Stanweld. The head of the bolt extends into the slots in the lugs, and the cap, through which the bolt extends, is fitted over the two lugs, thus clamping the whole together when the nut is applied to the end of the bolt. The tire is detached by removing the nut, cap, and **T** bolt, and prying the ring from the groove in the rim.

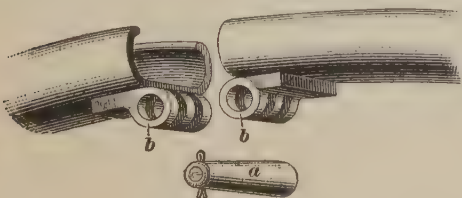


Fig. 13

24. Transversely Split Rims.—In order to facilitate the removal of the tire, some demountable rims are split trans-

versely instead of being fitted with a quick-detachable device. A rim of this type can be sprung together after it has been demounted and the tire can then be removed or put on.

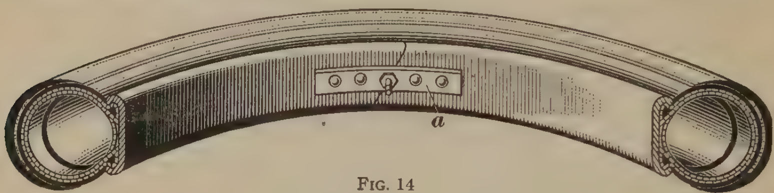


Fig. 14

The ends of transversely split rims are locked together in a variety of ways. In the Booth split rim a taper pin is used, as shown in Fig. 13. When mounted on the wheel, the ends of the rim are held together by a taper pin *a* that passes through brackets *b* on the ends of the rim. The tire is removed by first demounting the rim and then taking out the taper pin. The one end of the rim can then be pressed down and sidewise, thus contracting its circumference and permitting the tire to be detached.

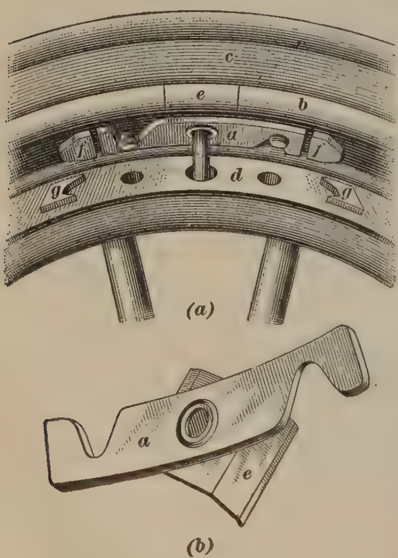


Fig. 15

25. The Baker bolted-on demountable rim makes use of an anchor plate for locking the ends of the rim in position, as shown in Fig. 14. The rim is split diagonally at the valve stem and the ends are held together by a plate *a*, which fits over four studs carried by the rim. A fifth hole in the plate allows the valve stem to pass through. The tire may be removed after the rim has been demounted, by taking off the anchor plate and bringing the two short sides of the rim together, thus reducing its circumference.

26. A different form of locking device for a transversely split rim is shown in Fig. 15, which shows the device applied to the Detroit demountable rim. A latch, or cross-tree, *a* is used to lock the ends of the rim in place, as shown in view (*a*), in which view the demountable rim *b* with the tire *c* is in position to be placed on the wheel rim *d*. When locked, the latch *a* engages with two buttons on the inside of the rim. The openings for the buttons are cut at an angle so that as the latch is turned to be locked in place, the rim is expanded. Dirt and water are prevented from entering the tire casing by a small filler segment *e* that is secured to the locking cross-tree. When assembled, the tire-valve stem extends through the center of the latch and the filler segment. A detail of the latch and segment is shown in view (*b*).

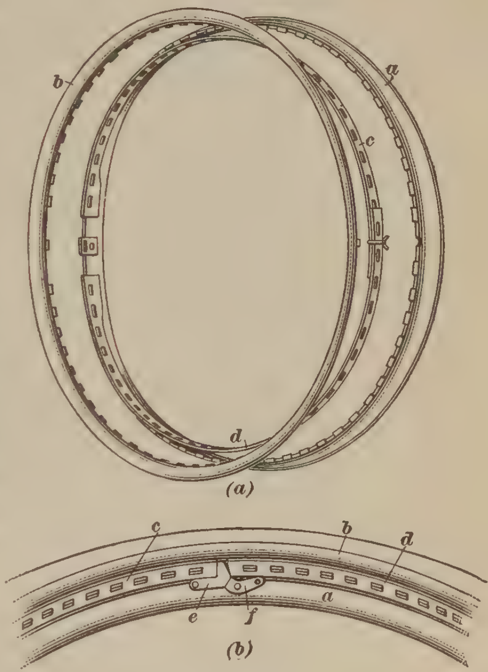


Fig. 16

The demountable rim is prevented from slipping around the wheel rim by blocks *f* and *g* that engage with each other when the rims are assembled. An expanding tool that is furnished with the rim may be used for expanding the rim to remove the filler segment if it should become rusted.

27. Circumferentially Split Rims.—An example of a demountable rim that is split circumferentially is the Stanweld rim, number 30, which is shown in Fig. 16. The sections of the

rim are shown in detail in view (*a*). The base of the rim is in two sections *a* and *b* that can be locked together by two semi-circular locking rings *c* and *d*, which are shown tied together in order to show their construction. Each section of the rim has a series of lugs that can be made to engage with the slots in the locking rings and hold the rim together. One end of each locking ring is securely riveted to the wide section *a* and the free ends may be locked by means of a swinging latch when assembled, as shown in view (*b*), in which the various parts are lettered the same as in view (*a*). The latch consists of the main latch *e* and a cam-latch *f* that is used for locking in place the main latch.

The tire is removed from the rim by first opening the cam-latch *f* and then the rim latch *e* with a screwdriver, small punch, or similar tool, and prying the locking rings from the lugs, beginning at the free ends and working toward the riveted ends. The two sections of the rim can then be removed, one at a time. When locking the rim, the reverse operation is gone through.

AIR VALVES, LUGS, AND INNER TUBES

28. Tire Air Valves.—In the United States, the kind of check-valve in universal use for admitting air under pressure to a single-tube automobile tire or inner tube and retaining it therein, is that known commercially as the **Schrader valve.** The one made for inner tubes is illustrated partly in section in Fig. 17 (*a*). In (*b*) the air check, which is known commercially as the *valve insides*, is shown to an enlarged scale.

Referring to view (*a*), the stem head *a* is placed inside the inner tube, and a metal washer *b* is clamped down against the tube by means of the nut *c*, which fits on the threaded body of the hollow stem *d*. Between *b* and *c* is a guard, or spreader, *e*, called the *bridge clip*, that prevents the inner tube from coming into contact with the nut *c*. This guard also fits against the side of the shoe, so as to make a tight joint for the bearing surface of the inflated inner tube. The stem *d* is flattened on two opposite sides, as shown at *f*, so that it can be held with a wrench to prevent its twisting around while tightening the nuts.

The nut *g*, when tightened, presses the leather washer *h* against the felloe. The end *j* of the hole *i* is threaded to receive the valve insides.

The outside of the valve stem receives a small cap *k*, which protects the valve from dust and other foreign matter. At the same time, loss of air from the inner tube, in case the air check-valve should leak, is prevented by the rubber packing disk, or washer, *l*, which bears against the end of the valve stem when the cap is screwed in place. A large dust cap *m* screws over the larger portion of the stem against a leather washer *n*, and thus forms a protection for the entire end of the stem.

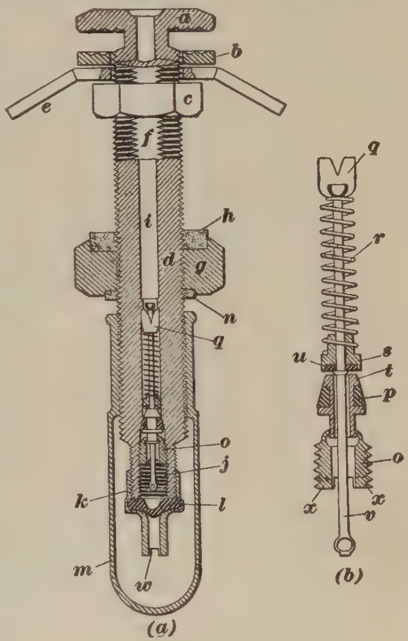


FIG. 17

29. When the threaded piece *o* is screwed down to the proper position, as shown in Fig. 17 (*a*), the conical rubber packing ring *p*, view (*b*), presses against a corresponding coned surface in the hole through the stem, making an air-tight joint. At the same time, a thin brass cup-shaped piece *q* bears against a square shoulder farther down in the hole, so as to compress the coiled expansion spring *r*, and thus force the valve *s* up toward the valve seat *t*. The valve *s* is provided with a soft-rubber valve disk *u*, against which the comparatively sharp edge of the valve seat *t* bears when the valve is closed. When air is passing through the valve into the inner tube of the tire, the valve *s*, together with its rubber disk *u*, is forced away from the valve seat *t* by the pressure of the air against the valve disk.

When it is desired to allow the air to escape, the valve can be opened against the pressure of the air in the inflated tube by pressing against the end of the solid stem *v*. The only part rigidly attached to this stem is the valve *s*, so that when the stem *v* is pushed in against the coiled spring *r*, the valve *s* is forced away from the valve seat *t*. As soon as the valve and seat are separated, the air can escape.

30. In order to provide a ready means of screwing the valve into place and removing it, the small cap *k* has a slot *w* across an extension of its outer end and the end of the part *o* is cut away so as to leave projections *x*, over which the slot *w* fits. The two parts together thus operate as a screwdriver

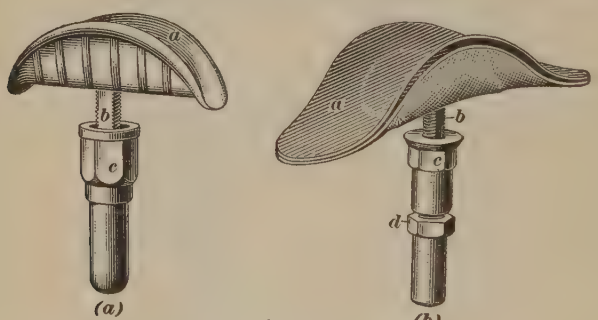


FIG. 18

and a slotted screw head. The stem-like extension of the cap *k*, across which the slot *w* is cut, fits loosely into the end of the valve stem, and can therefore be readily inserted to screw the valve into place. The rubber packing *l* in the small cap has a depression on the side next to the valve, in order to prevent it from striking the end of the small stem *v* in case the latter happens to project beyond the end of the main valve stem *d*. The rubber packing is correspondingly crowned on the side opposite the depression so as to secure sufficient thickness of material. The small solid valve stem is flattened at both ends so that the parts of the valve will not fall apart when removed from the main valve stem.

On examining a leaky air valve, it is sometimes found that the leak is due to the packing ring *p* being put on incorrectly

when the valve insides were assembled. The obvious remedy of this is to remove the ring and replace it so that its conical surface coincides with the surface of the valve seat *t*.

Schrader valves are made with different lengths of stems to suit different sizes of inner tubes and thicknesses of wheel felloes.

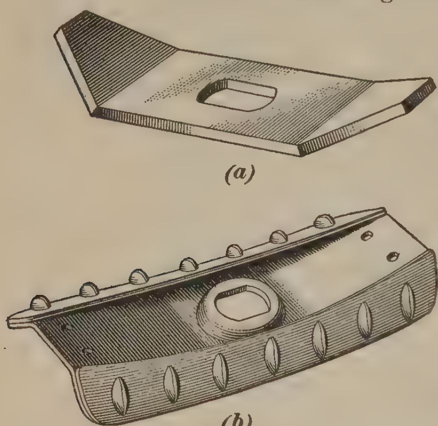
31. Tire Lugs.—Two forms of devices for fastening an ordinary, or regular, clincher tire on the wheel rim are illustrated in Fig. 18. The lug shown in view (*a*) has a rubber-covered head, or spreader, *a*, inside of which is a piece of metal formed to a suitable shape, and to which is attached the threaded stem *b*. The nut *c* is made cap-shaped to protect the stem. A leather washer is usually placed between the nut and the felloe of the wheel, in order both to make a tight joint and to reduce the liability of the nut to work loose.

In view (*b*), the head *a*, which fits inside the shoe between it and the inner tube, is covered with canvas on the side that comes against the shoe and with leather on the other side. The metal portion of the head lies between the leather and the canvas. The stem *b* has the same form as the stem of the lug just described and passes completely through the nut *c*. A locknut *d* is also placed on the stem, and it is screwed down against the nut *c* in order to lock this nut in place after it has been sufficiently tightened. The locknut *d* is cap-shaped and is closed at the end to protect the stem.

In order to eliminate the necessity of using a wrench for tightening the tire lugs, a wing nut, or thumb nut, is sometimes used on lug stems.

32. The head of a tire lug, clip, or clamp must be of such form as to fit closely and smoothly against the inside of the tire casing. It should also fit against the wheel rim in the same manner when the latter is not completely covered by the casing; otherwise, a hole will be blown through the inner tube or the tubes will be locally stretched and permanently distorted around the head of the lug. The excessive local stretching will weaken the rubber and ultimately will likely cause a hole, which may not occur, however, until the tube has been removed, put in a casing, and inflated again.

Tire clamps, or lugs, are usually omitted on regular clincher tires of the smaller sizes, say up to and including $3\frac{1}{2}$ inches diameter of cross-section, in which case the friction of the bead in the rim is depended on to keep the tire from creeping around the rim. The tires seem to be very effectively held in this manner as long as they are fully inflated. However, if the tire on a rear wheel is run after it has become partly deflated, it is liable to creep around on the rim. When this creeping occurs, there is danger of shearing or of tearing the valve from the inner tube.



(a)

(b)

FIG. 19

If tire clamps are not used on a rim that has holes for them, the holes should be tightly plugged. The plugs used for this purpose must be smoothed down flush with the rim where the tire bears against it.

Tire clamps serve to prevent the shoe from being pulled from the rim when turning curves, and also to prevent it from creeping around on the rim. The results of leaving clamps off seem to indicate that they are not actually necessary except when the tire becomes deflated.

33. Bridge Clips.—Several forms of bridge clips are used with Schrader valves in order to protect the inner tube at the point where the valve stem is attached, and also to prevent creeping of the tire on the rim. The clip is a large, specially shaped washer, resembling the head of a tire lug, that surrounds the valve stem close to the inner tube, as shown at *e* in Fig. 17 (*a*). A detailed view of this clip is shown in Fig. 19 (*a*). This is a very common form of bridge clip. A much larger clip than this is the Michelin bridge clip shown in view (*b*). It is shaped to conform approximately to the shape of the inner tube

and is provided with short projections along each side that tend to prevent it from slipping around the tire and thus to relieve the valve stem of a certain amount of strain.

Another form of bridge clip, applied to an inner tube, is shown in Fig. 20. The metal clip *a* is supported by a nut *b* on the valve stem and a metal washer next to the tube. The inner tube is reinforced at this point by an additional thickness of rubber that is cemented on.

A clip made up like the tire-lug head shown in Fig. 18 (*a*) is largely used. Any form of bridge clip can be used on any type of double-tube tire, although some tire companies recommend special clips for different types of tires. For instance, the Diamond Rubber Company furnishes a special clip to be used with their quick-detachable and regular clincher tires, while the clip shown in Fig. 18 (*a*) is to be used with straight-side tires. Attention is called to the fact that the proper size bridge clip must always be used, because one made for instance for a 5-inch tire will not fit a $2\frac{1}{2}$-inch tire, and vice versa.

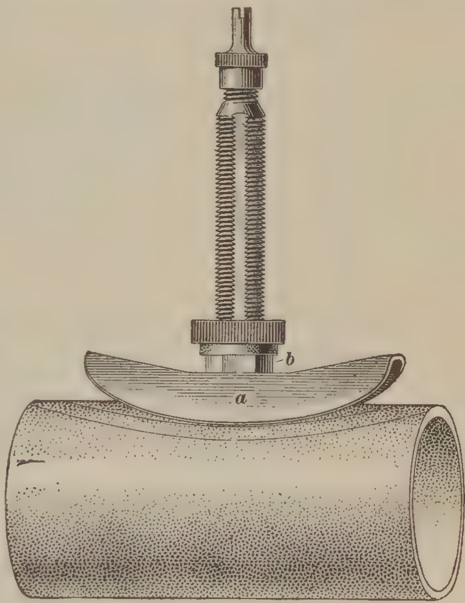


FIG. 20

34. Designation of Tire Sizes.—The size of an American pneumatic tire is designated by first giving, in inches, its outside diameter over the tread and then the diameter of the circle that closely conforms to the outside cross-section of the tire. Thus, when speaking of a $32'' \times 4''$ tire, it means that the

tire has an outside diameter of 32 inches and that a circle 4 inches in diameter will approximate the external outline of the cross-section.

Tires are made in certain standard sizes that are agreed on by tire makers; these sizes are changed, however, from time to time, as occasion demands. Tires are also made to suit the wheel rims of foreign cars, in which case their size is stated in millimeters. The millimeter is $\frac{1}{1000}$ meter, the length of the meter being 39.37 inches, nearly.

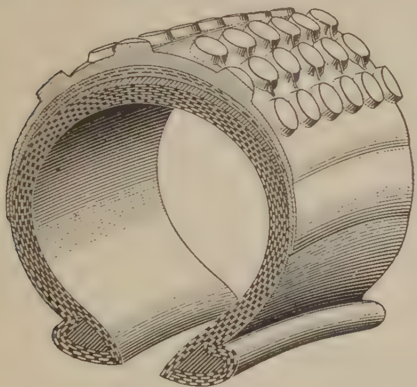
35. Oversize Tires.—Double-tube tires larger than the standard sizes are sometimes used in order to increase the cross-section of a tire air cushion, as well as to give a heavier and more wear-resisting tread. These are known as *oversize tires* and are applied without changing rims. They are $\frac{1}{2}$ inch larger in cross-section and 1 inch larger in diameter than the uniform sizes with which they interchange. For instance, the oversize tire for a $32'' \times 4''$ rim is $33'' \times 4\frac{1}{2}''$.

As a general thing, it is advisable to use the corresponding size of inner tube with any casing, although the Goodyear Tire and Rubber Company has on the market an inner tube constructed especially to be used with a larger sized casing, at least in the smaller sizes; this practice is uncommon, however. With this special tube, an oversize casing can be fitted to a rim and the standard-sized inner tube retained. Thus, an inner tube intended for a $32'' \times 3\frac{1}{2}''$ casing can be used in a $33'' \times 4''$ casing. However, unless special provision is made it is not advisable to make a practice of using an inner tube smaller than is intended for a casing. An inner tube larger than the proper size for a casing can also be used temporarily, as in an emergency. A tube that is too large, however, wrinkles in the casing and is liable to chafe through quickly or crack at the short bends of the wrinkles.

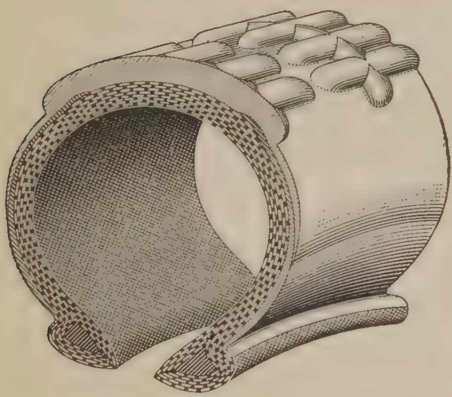
Standard sizes of tires can always be recognized by the fact that the tread diameter is given in even inches; oversize tires have the tread diameter in odd inches. Thus, a $36'' \times 4''$ tire is a standard size, while a $37'' \times 4\frac{1}{2}''$ tire is an oversize tire. The use of oversize tires is advisable when standard size tires

on a car are overloaded and hence wear out faster than they should.

36. Permanent Tire Treads.—The tread of tires is made in various contours, the most common one being the *plain tread*, shown in Figs. 2 to 5. *Raised treads* of various forms are also used extensively for the purpose of giving protection against side slipping; some of the most common examples are shown in Fig. 21. In view (*a*) is shown the *Bailey tread*, in which conical rubber studs project from the tire. The *Goodrich safety tread* is shown in view (*b*). The raised cross-bars tend to prevent fore-and-aft spinning of the driving wheels, while the longitudinal bars tend to prevent side slipping. The *Firestone non-skid tread*, view (*c*), consists of raised rubber letters that grip the road and prevent slipping. Permanently attached tire treads are sometimes made of leather and studded



(*a*)



(*b*)

(*c*)

Fig. 21

with steel rivets or studs placed in a manner similar to that shown in Fig. 21 (*a*). Many forms of tire treads other than those mentioned are on the market, each designed with a view to prevent slipping and each having its peculiar advantages.

TIRE MAINTENANCE

INFLATION OF TIRES

37. Loads and Air Pressure for Tires.—There seems to be no very close agreement either among the manufacturers or the users of tires as to just what maximum load a tire can carry or what should be the pressure of inflation. This condition is probably due to the fact that tires of the same size are made of different thicknesses by tire makers, and also that the most suitable inflation pressure depends to some extent on the nature of the road over which the car is run. It is always safe to assume, however, that a tire will not show appreciable bulging between the wheel rim and the roadway if it is properly inflated. In any case, it is not possible to formulate a general statement as to just how slight, according to actual measurement, this bulging should be. A thin, flexible tire will naturally bulge more than a heavy, stiff one, provided both are inflated to the same pressure.

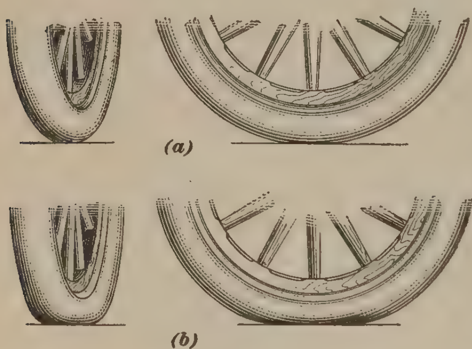


Fig. 22

The lower part of a wheel with a properly inflated tire is shown in Fig. 22 (*a*), and a *soft tire*, as one not inflated hard enough is called, is shown in (*b*).

38. One of the most important things in the care of automobile tires is to keep them properly inflated. The only practical way to determine whether a tire is sufficiently inflated is to use a pressure gauge. Furthermore, if the bad results of under inflation are to be avoided, it is not enough to test the pressure at long and varying intervals but a regular and frequent test should be made, say, twice a week.

Fixed rules are used by some manufacturers for determining the proper air pressure for different sized tires. For instance, the Diamond Rubber Company uses the rule that the required air pressure per square inch equals the diameter of the cross-section of the tire multiplied by 18. Thus, a $36'' \times 4''$ tire requires an inflation pressure of $4 \times 18 = 72$ pounds per square inch, by this rule. Other manufacturers use different constants varying from 15 to 21, while in still other cases no definite rule is followed, tables being compiled from experience.

39. Table I gives the inflation pressures recommended by the Firestone Tire and Rubber Company, as well as the safe load for front and rear wheels on a car without passengers.

40. If an automobile is run at high speed for any length of time, the tires will be heated considerably and the air pressure within them will thus be slightly increased. Although this increase of pressure does not endanger a new tire of good quality, it will do harm to an old tire that has become weakened by long use. It is therefore advisable to reduce the air pressure in such tires by slightly opening the tire air valve.

41. Methods of Inflating Tires.—The means used for inflating pneumatic tires may be classified under four general heads; namely, *hand-operated tire air pumps; engine-driven tire air pumps; spark-plug tire air pumps;* and *storage tanks* containing compressed air or carbonic-acid gas.

TABLE I

LOAD AND AIR PRESSURE FOR PNEUMATIC TIRES

Size of Tire Inches	Air Pressure Pounds per Square Inch	Load per Wheel Pounds	
		Rear	Front
28×3	50	350	450
30×3	50	375	475
32×3	50	375	475
34×3	50	400	500
36×3	50	425	525
29×3½	60	450	550
30×3½	60	475	575
31×3½	60	500	600
32×3½	60	525	625
33×3½	60	550	650
34×3½	60	575	675
36×3½	60	625	700
30×4	70	550	700
31×4	70	575	725
32×4	70	600	750
33×4	70	625	775
34×4	70	650	800
35×4	70	675	825
36×4	70	700	850
37×4	70	725	875
38×4	70	750	900
40×4	70	800	950
42×4	70	850	1,000
32×4½	80	800	1,000
33×4½	80	850	1,050
34×4½	80	900	1,100
35×4½	80	950	1,150
36×4½	80	1,000	1,200
37×4½	80	1,050	1,250
38×4½	80	1,100	1,300
40×4½	80	1,200	1,400
42×4½	80	1,300	1,500
33×5	90	950	1,200
34×5	90	1,000	1,250
35×5	90	1,050	1,300
36×5	90	1,100	1,350
37×5	90	1,150	1,400
38×5	90	1,200	1,450
39×5	90	1,250	1,500
41×5	90	1,350	1,600
43×5	90	1,450	1,700
36×5½	95	1,250	1,500
37×5½	95	1,300	1,550
38×5½	95	1,350	1,600
40×5½	95	1,450	1,700
37×6	100	1,350	1,600
39×6	100	1,450	1,700
41×6	100	1,550	1,800

HAND-OPERATED TIRE PUMPS

42. Classes of Hand-Operated Pumps.—While tire inflation by hand-operated means has largely given way to inflation by power-driven pumps, yet the hand pump will doubtless always be used more or less, especially for inflating the smaller-sized tires.

Hand-operated tire pumps are made *single acting*, compressing the air on the downward stroke only, or *double acting*, compressing the air on both the upward and the downward stroke. Double-acting pumps usually compress the air in two stages; that is, the air is partly compressed on the one stroke and fully compressed on the next stroke. Such pumps are called *double-acting compound tire pumps*.

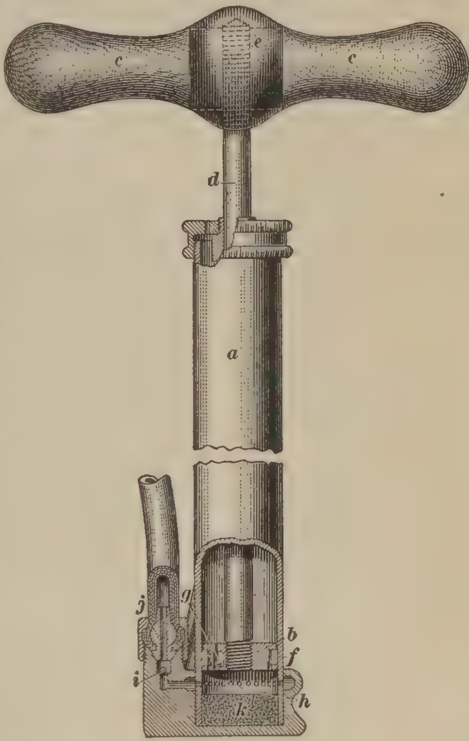


FIG. 23

43. Single Acting Hand-Operated Pumps.—A single-acting tire air pump of simple construction is shown in Fig. 23, which is a sectional view of the Pitner single-acting pump. This pump consists essentially of a barrel *a* and a piston *b* that is actuated by hand by the wooden handle *c* and the piston rod *d*. The wooden handle is first driven into a brass collar *e*, after which the rod is screwed through both. The piston *b* is made air-tight by means of a leather piston ring *f* that fits in a groove around the

piston. An air space behind the leather ring provides an air cushion that presses the ring against the barrel of the pump.

Air is taken into the barrel of the pump on the upward stroke of the piston. During this stroke ports *g* in the piston are open and air flows through holes in the cap around the piston rod and into the lower part of the barrel through the ports *g*. On the downward stroke of the piston, the ports *g* are closed by ball checks and the air contained in the lower half of the pump is forced out through small holes *h*, past the ball check-valve *i*, and into the tire hose connection *j*. The check-valve *i* prevents air from entering the pump from the tire on the upward stroke of the piston.

44. The pump shown in Fig. 23 is so designed that as soon as the piston passes the small holes *h* at the base of the pump no more air can escape and thus a small air cushion is formed, which prevents the piston from striking the bottom with a sudden jar. A felt pad *k* is placed below the air cushion to absorb surplus oil and keep it out of tires. An extension, which is not shown, is placed on the base to receive the foot of the operator in order to hold the pump while it is being operated.

45. Single-acting tire pumps are also made in forms differing somewhat from that shown in Fig. 23, but the principle of operation is, of course, the same. Most pumps make use of cup-shaped leather washers instead of leather piston rings for making them air-tight. Such pumps depend on the collapsing of the cup leather for admitting air to the barrel, and hence are not provided with ports and check-valves in the piston.

46. Double-Acting Hand-Operated Pump.—A typical double-acting tire pump is shown in Fig. 24, which is a sectional view of a pump manufactured by the Judd & Leland Manufacturing Company. In order to make this pump double acting, it has two barrels *a* and *b*, each of which is provided with a piston and piston rod. The barrels are connected at the bottom by an air passage *c*, but they are not connected at the top. The inlet is near the top of the larger barrel *a* through two holes, one of which is shown at *d*, and the outlet is from two holes located near the top of the smaller barrel *b*. The outlets

connect with the tire hose by means of a passage represented by the dotted lines *e* in the bracket *f*. A stuffingbox *g* that surrounds the piston rod in the upper end of the smaller barrel prevents air from escaping at that point. Each piston is provided with a cup-shaped leather washer; the leather in the larger barrel is placed so that the piston operates on its downward stroke, while the leather in the smaller piston forms an air-tight plunger on its upward stroke. Both pistons are operated by one handle *h*.

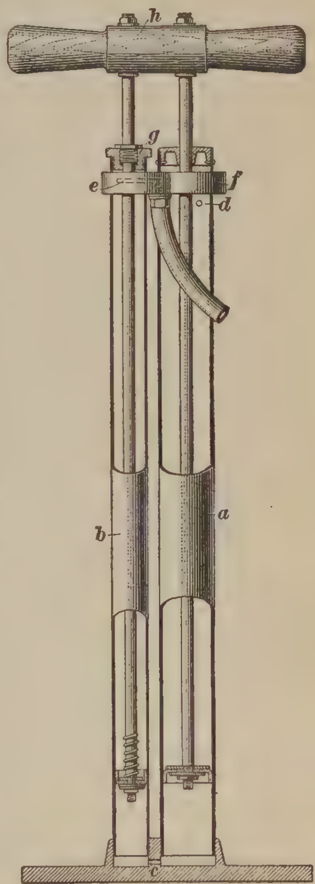


Fig. 24

47. Being a double-acting pump, air is discharged from the outlet during both the downward and upward strokes of the pistons. During the downward stroke, air is drawn in at the upper end of the larger barrel *a* and fills the space above the piston. At the same time the air that was already in the larger barrel beneath the piston and in the smaller barrel *b*, is forced past the smaller piston and into the air hose and tire by way of the outlet passage *e*. The air that remains in the smaller barrel at the end of this stroke is compressed to a certain extent.

During the second, or upward, stroke the air remaining in the smaller barrel *b* is forced out and into the tire by the smaller piston. This air has been previously compressed; hence, on this stroke the pump is a true compound pump. On the downward stroke, however, the air that is forced out has not been precompressed. Besides forcing the air out during its upward stroke, the smaller

piston also draws air into the pump through the holes *d* and past the larger piston, so that both barrels are filled with air at the end of this stroke and are ready for the descent of the pistons on their downward stroke, which has been explained.

The successful operation of this type of tire pump depends on the condition of the cup leathers, which must be soft and pliable. When operating properly, air cannot be forced upwards past the larger piston or downwards past the smaller one, but when air is forced in the opposite directions the cup leather collapses and allows it to pass. This action of the cup leathers makes separate check-valves unnecessary.

48. Hand pumps are made with as many as three or four barrels, three barrels being quite common. Such pumps are always double acting and usually compound as well. A tire can doubtless be filled more quickly with a double-acting compound pump, but many drivers prefer the more simple single-acting pump because all of the work is done on the downward stroke. The greater ease with which this pump can be used makes up for the longer time required to inflate a tire.

ENGINE-DRIVEN TIRE PUMPS

49. Application.—Many makes of automobiles are now equipped with power-driven tire pumps that are driven from some part of the engine. Where such a pump is not a part of the regular equipment, provision is made in some cases for its installation. The engine-driven tire pump is simply a small single-acting air compressor, having from one to four cylinders, that is connected to some moving part such as the magneto or water-pump shaft, or the transmission shaft, by means of a metal clutch or by sliding gears. By the use of such a pump, an average sized tire can be inflated in from 1 to 5 minutes and without the arduous labor necessitated by the hand pump.

50. Single-Cylinder Engine-Driven Pumps.—An example of a single-cylinder engine-driven tire pump is given in Fig. 25, (*a*) being an external side view and (*b*), a vertical section. This pump is used on many Pierce-Arrow automo-

biles. It belongs to the class that makes use of but one valve, the air being admitted through small ports. The tire pump is driven from the transmission countershaft by means of a jaw clutch, one member of which is free to slide on the tire-pump shaft *a*.

The piston and connecting-rod of the tire pump are constructed similarly to those of the gasoline engine. Near the

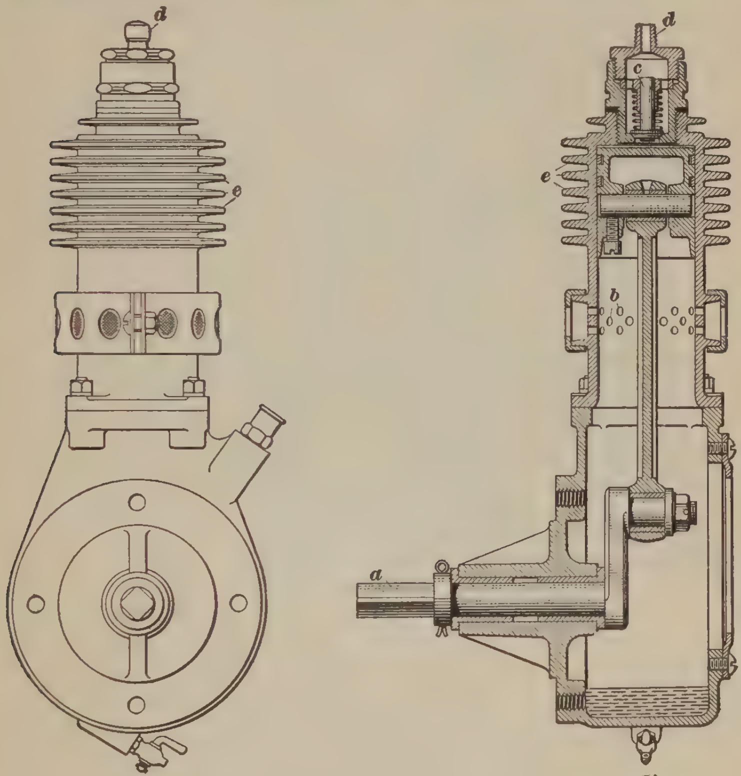


FIG. 25

completion of the downward stroke of the piston, the inlet ports *b* are uncovered and fresh air is drawn into the cylinder. On the upward stroke of the piston, the check-valve *c* is lifted off its seat and the air is forced out through the tire hose connection *d*. The cylinder of the pump is air-cooled, being surrounded

by flanges *e* for the purpose of increasing the radiating surface. The moving parts are lubricated by the splash system.

This pump will work most efficiently when run at 300 revolutions per minute. It is started and stopped by a lever, by means of which the jaw clutch can be engaged or disengaged. The pump should be put into action with the engine running slowly and should not be run at a greater speed than just given; otherwise, it will waste power by heating.

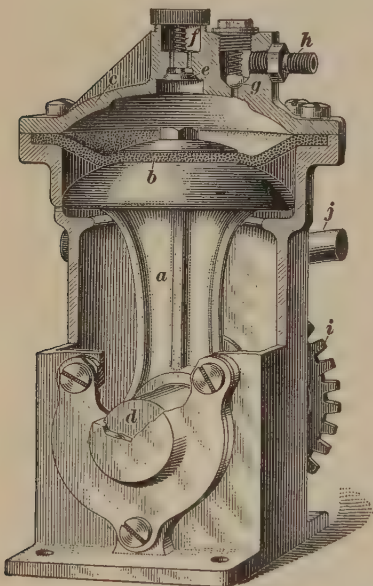


FIG. 26

51. Diaphragm Tire Pump.—A single-cylinder tire pump of peculiar construction is shown in Fig. 26, which is a part sectional view of the Taylor "Noil" diaphragm pump. This pump is so constructed that it is impossible for lubricating oil to become mixed with the air that is being forced into the tire, hence, the name Noil. The ordinary reciprocating piston is not used in this pump but, instead, the upper end of the connecting-rod *a* terminates in a large, mushroom-shaped disk, to which is secured the soft rubber diaphragm *b*. This diaphragm is also secured to the body of the pump by being clamped between it and the head, or cap *c*, thus completely separating the lower portion of the pump from the upper portion, where the air is compressed.

The connecting-rod is reciprocated by means of an eccentric on the shaft *d*. On the downward movement of the connecting-rod and diaphragm, the inlet valve *e*, which is supported by a bronze spring *f*, is drawn open and air drawn into the pump. On the upward stroke, the diaphragm forces the air out past

the ball check-valve *g* and by way of the tire hose connection *h*, to the tire.

The Taylor Noil pump can be driven from any exposed moving shaft but is usually driven from either the magneto or the water-pump shaft. The sliding gear *i* is operated by a lever *j*, by which it can be thrown in and out of mesh with a gear on the revolving shaft. This pump operates most efficiently at a speed of about 600 revolutions per minute. Flanges on the cover of the pump help to radiate the heat resulting from the compression of the air.

52. Multiple-Cylinder Tire Pumps.—The most common form of multiple-cylinder tire pump is air cooled and has

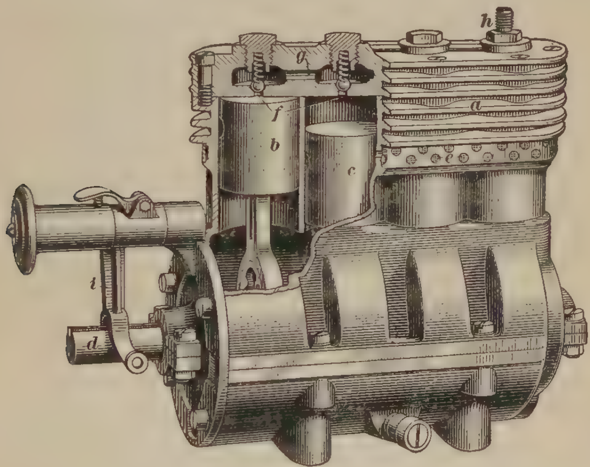


FIG. 27

the cylinders cast in one piece. Usually the pump has either two or four cylinders arranged vertically, although an exception to this rule is the Abbell pump, which has three cylinders arranged horizontally. The pistons are driven either by cranks or by eccentrics, the lower ends of the connecting-rods forming the straps. In some pumps the pistons are plain and carry no rings, while in other cases they are provided with rings like gasoline-engine pistons. Pump cylinders are sometimes surrounded by a water-jacket and cooled by water, although this is usually deemed an unnecessary refinement.

53. Fig. 27 shows a part sectional view of the Stewart four-cylinder air pump. The four cylinders are cast in one piece and are air cooled, being provided with horizontal flanges *a* for increasing the heat radiating surface. The four pistons, two of which are shown at *b* and *c*, are driven by eccentrics from the shaft *d*. The pistons are perfectly smooth, being simply small cylindrical pieces that have been ground accurately to size. The crank-case is divided horizontally in line with the shaft *d*, the upper half being cast integral with the cylinders. The air inlets *e* are screened. The outlets *f* are provided with ball check-valves and all open into a common passage *g*, from which the air-hose connection *h* on top of the forward cylinder leads. The mechanism *i*, located at one end of the pump, is for the purpose of connecting it to or disconnecting it from the driving shaft.

54. In operation, the action of the pump is the same as that of the Pierce-Arrow single-cylinder pump. On the downward stroke of the piston, the inlet ports *e* are uncovered and air rushes into the cylinder. On the upward stroke, the piston compresses the air and forces it out past the ball check-valve into the outlet passage *g*, thence to the tire connection and the tire.

SPARK-PLUG TIRE PUMPS

55. Tire pumps operated by the alternate compression and suction in the engine cylinder are made up in slightly different forms but operate on the same general principle. They are made to screw into the spark-plug hole of a cylinder, so that, when it is desired to inflate a tire, a spark plug is removed from one of the cylinders, the pump is screwed in its hole, and the motor is run idly on the remaining cylinders.

56. An example of the spark-plug tire pump is the Dewey pump, shown in section in Fig. 28. A differential, or double, piston is utilized, consisting of a large piston *a* that works in the outer cylinder *b*, and a smaller piston *c* that works in an inner cylinder *d*, the two pistons being connected by means of a hollow rod *e*. The pressure in the engine cylinder to which the

pump is attached forces the larger piston *a* upwards during the compression stroke in that cylinder. The pressure that is developed during this stroke varies from 50 to 75 pounds per square inch, depending on the compression pressure of the engine. This pressure per square inch is increased by the use of the double piston; hence, the smaller piston *c* is capable of pumping air into the tire at a much higher pressure per square inch than is developed at the larger piston *a*.

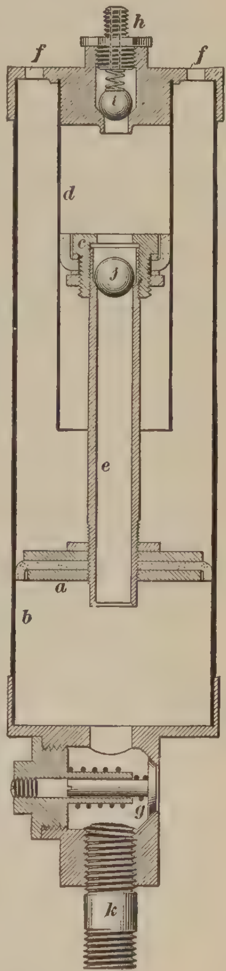


FIG. 28

57. The operation of the spark-plug tire pump is comparatively simple. On the downward stroke of the engine piston (either the suction or the working stroke), a partial vacuum is formed in the pump cylinder *b* beneath the larger plunger *a* and the pump pistons are forced downwards by atmospheric pressure through the openings *f* in the top of the pump cylinder. At, or about, the time that the pump plunger *a* reaches the bottom of its stroke, the breather valve *g* opens and allows fresh air to be drawn into the engine cylinder. This fresh air from the engine cylinder flows through the hollow rod *e* into the space in the inner cylinder *d* above the small plunger *c*, at the beginning of the compression stroke of the engine piston. The plungers are forced upwards during this stroke and the air in the inner cylinder is pumped into the tire by way of the tire hose connection *h*. A ball check-valve *i* prevents air from flowing back into the pump from the tire, and a similar check-valve *j* prevents air from flowing from the inner cylinder back into the outer one. The pistons of the pump are fitted with cup-shaped leather plungers, as shown. Different sized nipples *k*

can be secured from the makers of this pump to correspond to the different sizes of spark plugs.

It is claimed by the makers of the Dewey pump that no gasoline vapor from the engine cylinder reaches the pump on account of the amount of pure air taken in through the breather valve.

INFLATION FROM STORAGE TANKS

58. Storage tanks containing compressed air are usually found in all the better garages in the large cities. The air is pumped into the storage tank by an air compressor, which may be belt driven, or driven by a gasoline engine, or by an electric motor.

There are on the market small storage tanks for tire inflation that may be carried in the automobile. Such tanks, when empty, may be exchanged for full ones at various supply depots throughout the country. If cost is no consideration, the use of portable storage tanks is ideal for ease of inflation. However, as the air or carbonic-acid gas is stored in the tank under great pressure, extreme care must be exercised not to inflate the tires too much. It is advisable always to use a tire pressure gauge when inflating from a storage tank. Each portable tank will usually inflate from two to twenty-five tires with one filling, depending on the size of the tires.

The Prest-o-Tire tanks, which are of this type, are each charged with 5 pounds of liquid carbonic gas at a pressure of 900 pounds per square inch. If this gas is allowed to escape too rapidly the rapid decrease in pressure causes it to freeze, forming a snowy substance.

PUMP CONNECTIONS AND PRESSURE GAUGES

59. Tire Pumps Fitted With Gauges.—There are on the market tire air pumps that have a pressure gauge incorporated to indicate the pressure within the tire. When such a pump is used, the hose connection to the tire air valve must be constructed so that the tire air check-valve can be pushed and held off its seat. If this kind of a connection is not used,

the pressure gauge will register the pressure to which the pump compresses air, instead of the pressure existing in the tire.

60. Pump Connections to Tire Air Valves.—In Fig. 29 are shown two common types of air-pump connections. The one shown in (a), known as the *Perfection coupling*, has the outer casing a threaded internally to fit the outside thread at the end of Schrader valve stems. A fiber washer b makes a tight joint against the end of the valve stem and also against the end of the air barrel c, to which the hose leading to the source of air supply is attached. Owing to the construction, the outer casing a and its locknut d can turn freely on the air barrel, so that the hose will remain stationary while attaching or detaching the connection to the tire valve stem.

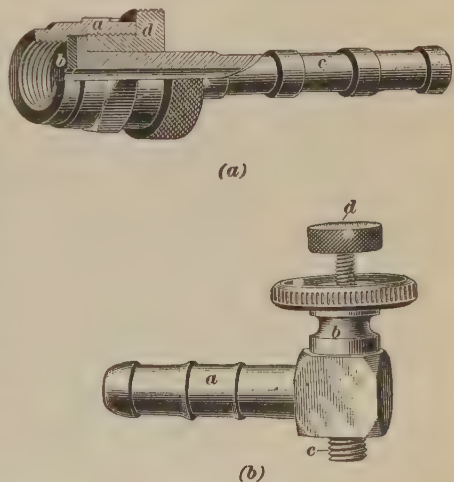


FIG. 29

The form of connection shown in (b), known as the *Keno Number 3* coupling, carries the hose, attached to the nipple a, at right angles to the tire valve stem. The connector b is threaded at c to fit the inside thread at the end of Schrader valve stems. A small screw d passes through the center of the connector b. When this is screwed in, it opens the air check-valve of the tire valve stem, thus adapting this connection to tire pumps fitted with a pressure gauge.

Most pump connections can be obtained with or without a central teat or screw for holding the air check-valve open. The nipples of pump couplings are made to fit tire-pump hose having an internal diameter of $\frac{3}{16}$ inch; larger pump hose is on the market, but is used only in connection with large compressed-air storage tanks.

61. While the Schrader valve stem is today the standard device used on American inner tubes, there are in use many

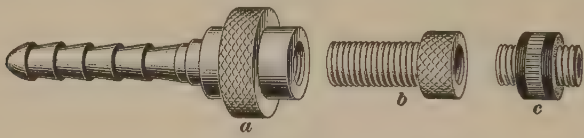


FIG. 30

foreign inner tubes having tire air valves that differ from the Schrader valve stem. The foreign valve stems mostly used are the *Michelin* and the *English Dunlop*.

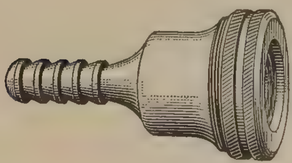


FIG. 31

To permit the same air hose to be attached to any one of the three tire valve stems mentioned, the form of connection shown in Fig. 30 has been placed on the market. In this type of connection, the casing *a* is threaded internally to fit the outside thread of the Michelin tire valve stem; the adapter *b* is threaded externally to fit the casing *a*, and internally to fit the outside thread of the English Dunlop tire valve stem; and the adapter *c* is threaded at one end to fit the internal thread of the adapter *b*, and at the other end to fit the internal thread at the end of the Schrader tire-valve stem.

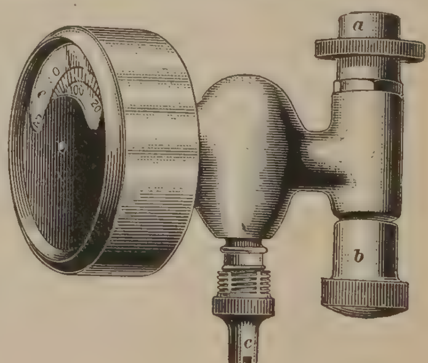


FIG. 32

62. A connection known as the *universal pump connection*, which may be fitted to any valve, is shown in Fig. 31. It is attached to the tire valve by simply pressing it on, when a rubber washer holds it firmly to the valve stem. It is removed by pulling it off. The rubber washer can be replaced by a new one when it is worn out.

63. Tire Pressure Gauges.—As insufficient inflation is the most prolific source of tire troubles, and as not even an expert tire man can tell by observation or by feeling a tire whether or not it is properly inflated, a tire pressure gauge

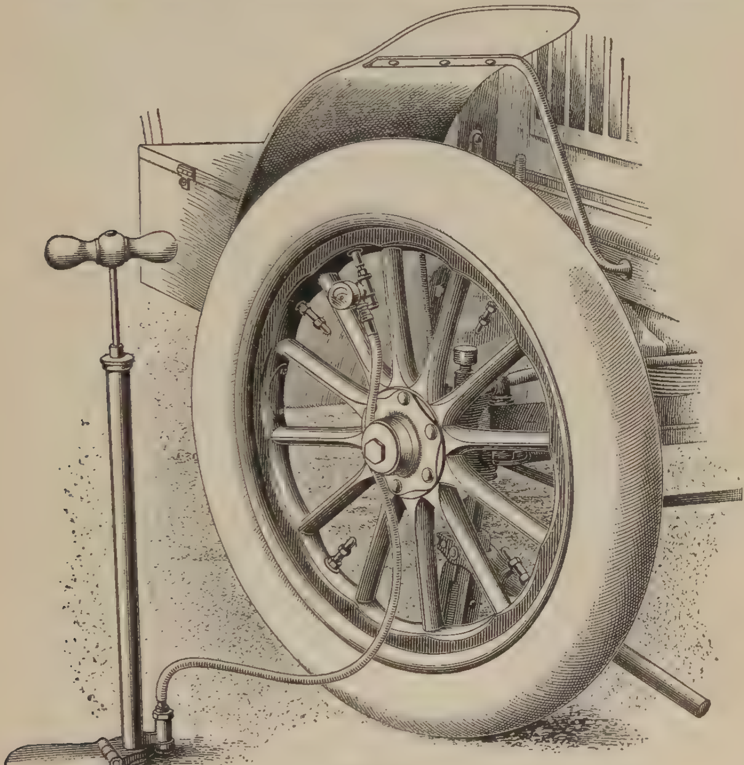


FIG. 33

should be used not only when inflating tires, but also for periodically testing the inflation pressure.

64. There are several reliable tire pressure gauges on the market. One type of gauge is shown separately in Fig. 32, and in Fig. 33 this same gauge is shown attached to a tire valve and pump. Referring to Fig. 32, the knurled nut *a*, threaded inside to fit the outside thread of Schrader valve stems, is used for connecting the gauge to the tire-valve stem. The

hose from the inflating pump is attached to the lower middle part of the gauge after the cap *c*, which is the same as that used on the valve stem of the tire, is removed. By screwing in the knurled head *b* after the gauge has been attached to the tire valve, the small air valve in the valve stem of the tire is forced from its seat. The air valve, which then operates as a check-valve, is in the part of the gauge immediately above the cap *c*. An indicating hand moves over the dial *e* in the cylindrical part of the gauge shown at the left-hand side. The dial is graduated to indicate the air pressure in pounds per square inch.

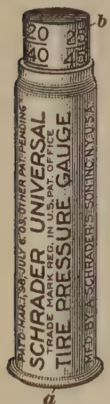


FIG. 34

65. Tire pressure gauges that are less expensive than that shown in Fig. 32 are on the market. Some of these operate on the same principle but are not provided with a device for forcing the small air valve in the valve stem from its seat. A pump connection like that shown in Fig. 29 (*b*) should be used in such a case.

66. Another simple form of tire pressure gauge is the *Schrader Universal tire pressure gauge*, shown in Fig. 34. A tire is tested by this gauge by simply holding the bottom *a*, in which there is an opening, to the tire valve. The air enters the air chamber in the gauge and forces the indicating sleeve *b* out; the pressure in the tire is read on the sleeve. The indicating sleeve remains at the point to which it has been forced by the air pressure until pushed back in place.

TIRE PROTECTORS AND ANTISKID DEVICES

67. Detachable Tire Protectors.—Ever since the advent of the pneumatic tire, inventors have been devising means of protecting it from puncture and at the same time rendering it less liable to side slip. In some cases, the devices have assumed the form of permanent tire treads; in other cases, they have taken the form of detachable protectors that are made in various styles and attached to the tire in a variety of ways.

A typical detachable tire protector, known as the *Woodworth tread*, is shown in Fig. 35. This protector is a steel-studded leather cover that is shaped to fit the tread of a tire and is held on by means of coil springs along each side. Some of the earlier Woodworth treads were held on by means of an endless crimped wire ring. The tread consists of an outer layer of leather, a middle layer of canvas, and an inner layer of thin leather. The studs on the middle portion have heads about $\frac{3}{16}$ inch thick; in addition to these studs there are two rows of thin head rivets on each side. The protector is applied while the tire is deflated and is intended to be held in place by friction when the tire is pumped up.

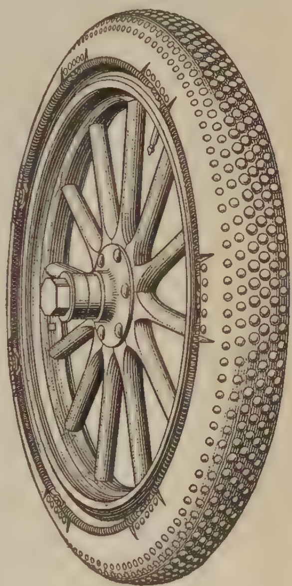


FIG. 35

Although tire protectors undoubtedly reduce the liability of puncture and skidding, they slightly reduce the resilience of the tire and the speed of the automobile.

68. Innerliners.—Inside tire protectors, made up of fabric and rubber and inserted between the tire casing and the inner tube, are sometimes used to reinforce tire casings. These find their best application in worn or injured casings, but they may also be used in new tires, although it is claimed by some that in new tires their advantage is offset by the extra heat and wear that they cause and by their added weight. Several forms of innerliners are on the market.

69. The *Interlock inner tire*, shown at *a* in Fig. 36, is an endless inside casing molded to fit the various sizes of tires. It fits between the regular tire casing *b* and the inner tube *c*, lapping over, or interlocking, on the inside, or next to the rim as shown at *d*.

Another form of innerliner is shown in Fig. 37 (*a*), which is a view of the *K and W Patent Reliner.* Instead of being endless like the Interlock, this reliner is split transversely. Innerliners of this form are held in place between the tire casing and the inner tube by a coating of cement, which may be put on at the factory or when the reliner is applied. They come from the factory rolled up as shown in view (*b*).

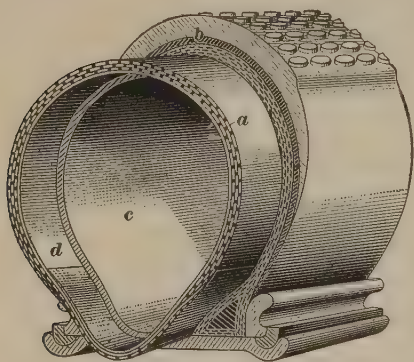


FIG. 36

A third form of innerliner is the endless type that does not overlap along the edge. An example of this form is shown in cross-section *a* in Fig. 38; this particular reliner is sold under the trade name of *Innershu.* It is similar to the Interlock in that it is endless like a tire casing but it has no overlapping flaps; the edges simply taper off at the edge of the casing.

70. Tire Chains.—In Fig. 39 is shown the Weed antiskid tire chain, which is the form of chain that is used exclusively to

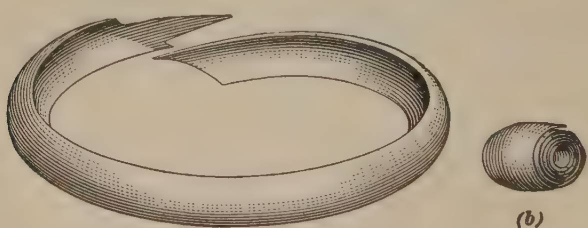

(*a*) (*b*)

FIG. 37

prevent tires from skidding. However, such a device will not protect them from puncture. The complete chain consists of two circumferential chains, one of which is shown at *a*, which

pass around the wheel just outside the rim, and are connected together by numerous cross-chains that pass over the tread of the tire. The ends of the circumferential chains are fastened together by means of very simple fasteners, as shown at *b*, one of which is provided in each chain. Both fasteners lie between the same pair of cross-chains. To put the chain in place, the wheel is jacked up or the chain is stretched out on the ground, or floor, either in front of or behind the wheel, and the wheel run on it. The chain can then be brought over the wheel and fastened in place. To remove the chain, the fasteners are opened and the chain permitted to drop to the ground, after which the wheel is run from it.

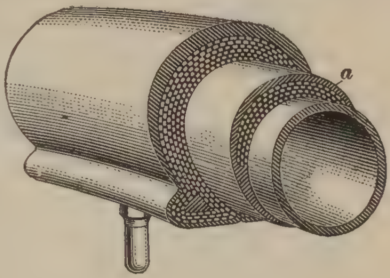


FIG. 38

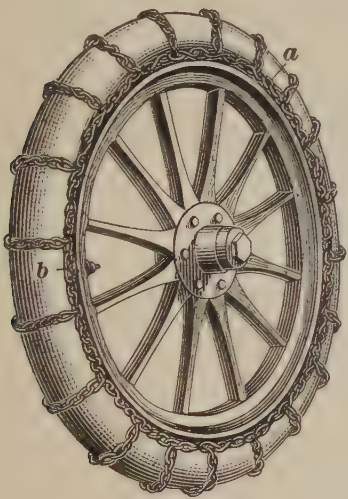


FIG. 39

71. Mud-Hooks.—If an automobile is running on very wet and muddy roads that are not macadamized, the tire chains sometimes do not give sufficient grip to drive the car, in which event the driving wheels spin around and the chains dig into the roadway until the axle or some other part of the car rests on it.

For running on extremely soft mud roads, a mud-hook of the form shown in Fig. 40 will be found very useful. When properly placed, this type of mud-hook projects far enough from the tire to get a good grip on the mud. It is advisable to put at least four hooks on each driving wheel, placing them at equal distances around the

wheel. If only one mud-hook is used on each wheel, as is sometimes recommended, it will grip the road until the rotation of the wheel lifts it from the roadway. If the engine is then pulling hard and the clutch is in full engagement, as is the ordinary condition of operation under the circumstances, the driving wheels will spin around until the hooks, one on each driving wheel, come into contact with the roadway again. This will suddenly stop the rotation of the wheels and cause excessive stresses on the transmission system, especially if the clutch is one that holds very tight when in full engagement. The use of four mud-hooks on each wheel will prevent spinning to a great extent and thus prevent any great stresses on the engine.

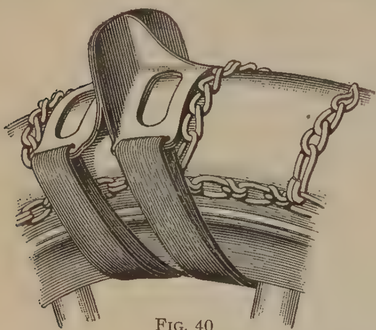


FIG. 40

AUTOMOBILE TIRES
(PART 2)

TIRE DETERIORATION AND REPAIRS

TIRE DETERIORATION

CAUSES OF CASING FAILURE

1. General.—An automobile tire carries practically the same guarantee as the automobile itself, namely, against imperfections in material or workmanship. It is true that defective tires occasionally go out from the factory, but in the great majority of cases, when the mileage falls far short of that for which the tire was sold, the cause can be traced to lack of proper attention, or to abuse in operation, and the owner suffers on this account in his claim for adjustment. It is the purpose of this Section to point out some of the most common of these abuses and their resulting effects on the tire, with a view of assisting the driver to obtain the greatest possible mileage from his tires, and to eliminate as far as possible the necessity for adjustment claims, usually so unsatisfactory to both parties concerned.

2. Underinflation.—A properly inflated tire is nearly round when carrying the full load of the car and its occupants. The strain in this case is distributed over the entire casing, and each portion is carrying its share of the load.

When a tire is underinflated, as shown in Fig. 1, a constant bending takes place in the fabric of the side walls, resulting, in time, in the breaking of the fabric along the line of the bend. The entire structure of the casing is weakened because the heat from the friction in the side walls softens the rubber cement, causes the layers of fabric to tend to separate, and lays the tire open to almost any trouble. In the case of a soft clincher tire, the side walls will rest on the rim flanges, and the casing will be cut just above the bead. This is known as *rim cutting*.

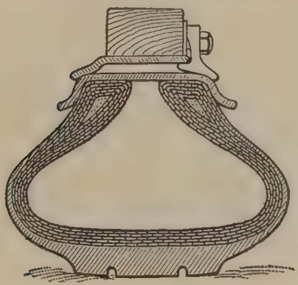


FIG. 1

3. Underinflation renders the tire less able to resist road shocks, also. A hard tire may hit an obstruction and bounce off, but a soft tire presents a broad, soft, surface to the road, and offers little resistance to injurious blows. Proper inflation greatly reduces the chances of a puncture, as, in addition to presenting less surface to the road, a hard tire will deflect sharp objects that would penetrate a soft tire.

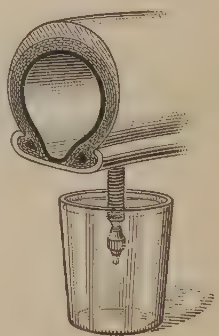


FIG. 2

Under no circumstances, should a car be run on a flat tire. Running on a flat tire even for a few rods is likely to ruin the casing and tube. If no spare tire or tube is available, the casing should be removed and the car run very slowly on the bare rim, to the nearest service station. Before putting on another tire the rim should be examined carefully for injuries, and cleaned thoroughly. Even though the rim is found unfit for further service, it is better to ruin the rim than the tire, as new rims are very cheap in comparison to tires.

4. It frequently happens that a tire becomes soft on account of leakage through the air valve and also past the cap

that screws on the valve stem. A test for such leakage can be made by immersing the end of the valve stem in water contained in a glass or some other vessel, as illustrated in Fig. 2. The leak is manifested by air bubbles issuing from the end of the valve stem. A little saliva placed on the end of the valve stem will indicate a leak in the air valve after the cap is removed from the stem. If leakage occurs when the cap is in place, it is of course an indication that both the valve and the cap leak. Replacing either one of these parts will generally stop the leak.

A leak through the cap of the valve stem is almost invariably due to deterioration of the small rubber disk packing in the cap. To test the cap, the large end should be placed to the lips, and an attempt made to blow through the opening. If it is possible to blow through the cap from the large end to the small end, the rubber washer should be pressed firmly into place, and another attempt made. If air can still be forced through the cap, it should be discarded for a new one. Both the cap and the valve insides are so cheap that it is only a waste of time to repair them. Extra ones should always be kept in the car for emergencies.

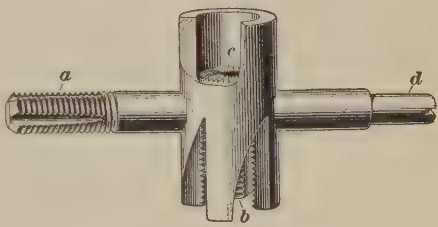


FIG. 3

5. The tool shown in Fig. 3 is intended for smoothing and dressing up battered valve stems of inner tubes. The tap *a* is used for cleaning up the thread inside the tubular valve stem; the die *b* for recutting the outside thread on the valve stem; and the facing cutter *c* for smoothing off the end of the valve stem where the rubber packing disk presses against it. The tubular part above *c* slips freely over the end of the valve stem to hold the tool in place when smoothing the end of the stem. The slotted end *d* is used to remove the small air

valve from the hollow valve stem and to screw the valve into it.

6. One result of driving a car on a soft tire is shown in Fig. 4. This illustration and other tire illustrations following have been made from photographs of actual tires, and show the condition of the tires just as they were removed from their rims. The fabric on the inside of the tire shown in Fig. 4 has been broken just above the bead. An example of rim cutting is shown in Fig. 5. Here the side walls of the tire are broken away from the bead. If the damaged part is small, a repair can be made.

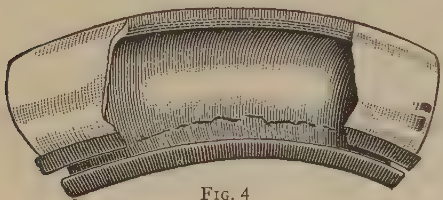


FIG. 4

Another effect of running on an underinflated tire is the pulling loose of the fabric along the outside of the shoe just above the angle between the bead and the main body of the tire. When the fabric thus pulls loose a large blow-out of the inner tube generally follows. Unless closely looked for, defects of this kind are sometimes difficult to locate, because as soon as the tire is deflated the torn part of the fabric will spring back against the body of the tire. The fault can be readily detected by bending the bead of the tire down by hand while the tire is off the wheel.

FIG. 5

7. Improper Driving.—Either skidding the wheels on a dry road by a too powerful application of the brakes or causing the wheels to spin by starting the car too suddenly, is extremely injurious to the tires, because the abrasion of the tires against the road cuts and tears away the tread of the shoe. If the brakes are applied so hard as to prevent the wheel from turning

when the car is traveling at considerable speed, the heat due to the sliding of the tire on the road will melt the rubber, and the destruction of the tire will then be exceedingly rapid. The result of locking the rear wheels and causing them to slide is shown in Fig. 6, where the casing is shown worn through the tread and part of the carcass.

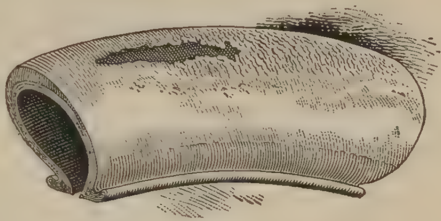


Fig. 6

Uneven application of the brakes causes unequal wear of the tires. The brakes should therefore be inspected occasionally, and adjusted when necessary, to keep the application the same on both sides of the car.

Continued driving in street-car tracks or wheel ruts will wear off the sides of the tire throughout its entire circumference. A section of a tire that is rut worn is shown in Fig. 7; the exposed tire fabric can be clearly seen.

Turning a corner at high speed causes an excessive side pressure on the tires. This, of course, has a tendency to tear the bead loose from the other portion of the tire. The side pressure may be sufficient to pull the tire from the rim, to bend the axle, or to break the wheel. Sharp corners should be turned at slow speed.

Fig. 7

Backing the rear tire against curb stones, or running the front wheels against the curb when stopping on a hill, should be avoided, as injury to the inner fabric may be the result. This injury may not be very large at first, but it will increase with continued use of the tire until eventually both the tube and casing may blow out.

Spinning the driving wheels in soft ground, snow, or grass, or slippery roads is likely to grind off the rubber tread, and even to tear the tread loose in pieces from the fabric.

When the rear wheels slip, and no non-skid chains are at hand, an effort should be made to back the car a short distance and then to go ahead, or the tire should be wrapped with rope, a board placed under each wheel, or, in fact, anything should be tried that will assist the tire in obtaining a firm grip on the ground.

8. Size of Tires.—Each car when it comes from the factory is equipped with the correct size of tire, proper allowance being made for the full load of the car. If considerable extra equipment, in the way of touring accessories and space for extra passengers, is added, it should be seen that the tires are of sufficient size to stand the extra weight.

9. Application of Tires.—It is very necessary that the tire be applied to the rim properly. Occasionally a straight-side tire is used on a quick-detachable clincher rim, but this should never be done without first fitting a filler bead in the rim clinches to prevent the edge of the rim from gouging into or chafing against the side wall of the casing. If best results are to be obtained from straight-side tires, they should be used only on straight-side rims, because it is considered advisable to have more spread between the beads in straight-side tires than is necessary with the beads of the clincher type. Straight-side rims are slightly wider at the base than are clincher rims.

When a universal quick-detachable rim is used, care should be taken that the rings are placed properly on each side of the rim to accommodate the type of tire being applied. In other words, if a clincher tire is being used, both rings must be turned with the rim clinches curved inwards, and when a straight-side tire is to be applied, both rings should be turned so as to fit the straight beads or straight sides of the casing.

10. Stone Bruise.—A tire running over a sharp stone at high speed may cause a blow-out immediately or the injury may not become known for a long time, but a blow-out

sooner or later is practically inevitable. The bruise may leave no mark on the outside of the tread but the fabric inside is broken as shown in Fig. 8, which shows the inside of the casing. The result of a stone bruise is that ultimately the pressure in the inner tube causes a rupture at the bruised and hence weakened part of the tire, followed generally by a rupture of the inner tube; such a rupture is called a *blow-out*.

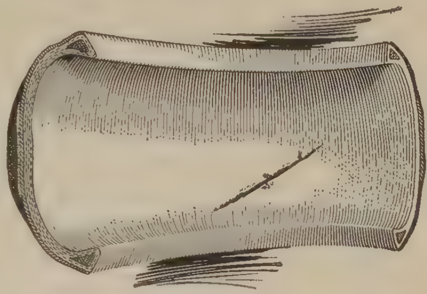


FIG. 8

11. Non-Parallelism of Wheels.—Improper alinement of the wheels, especially of the front wheels, is a common source of undue tire wear, because then the tires, instead of rolling over the road, will roll and slide at the same time. The effect is to grind off the tread and ruin the tire. The appearance of a front-wheel tire injured from this cause is shown in Fig. 9. If it is thought that front wheels are out of alinement, they can be tested by measuring the distance between the two wheels with a stick, both ahead of and behind the axle. The remedy is to correct the disalinement and have the tires retreaded if they are still in a condition to warrant the expense.

Excessive wear of the tire tread may be traced to loose bearings that allow the wheel to wabble, a loose or worn hub disk, slightly bent hub spindles, or other similar cause that prevent the wheel from running true. Wear caused by a wabbling wheel is more pronounced at some places than at others, the

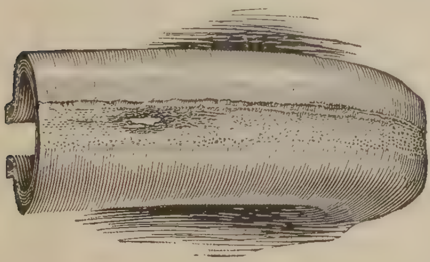


FIG. 9

greater wear being at the points where the wheel wabbles or shifts most.

12. Tire Chains.—Tire chains should not be used except when it is necessary and then they should be fitted loosely enough to work around the tires, and thus not press into the tread always at the same places. Under no circumstances should tire chains be tied to the spokes of the wheel; they must be left free to creep around the tire. If confined to one place, or if adjusted too tightly, they will tear or wear into the tire as shown in Fig. 10.

The smooth rounded surface of the cross links wears off from contact with the road, and very often sharp edges are left on the links. Care should be taken not to reverse the chains when next applied, as this would bring the sharp edges of the links next to the tire, resulting in the cutting of the rubber.

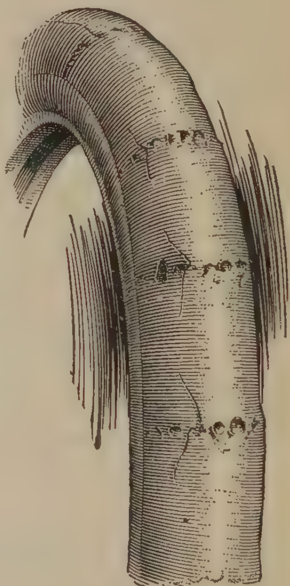


FIG. 10

The chains should be gone over carefully at frequent intervals, and cross-chains that are nearly worn through should be removed and new ones installed. The best practice is to put in a new cross-chain at every other place. When one of the old links breaks, the tire will slip just far enough to catch the next one, which will be new and strong enough to hold.

Rusty chains are injurious to tires; and to prevent rusting, the chains should be dried after using, dipped into a mixture of half kerosene and half lubricating oil, and hung up to drain. In addition to preventing rust, enough oil will be left on the chains to lubricate the wearing surfaces, but not enough to damage the tires. A little attention given to the chains occasionally will add materially to their life.

13. Storage of Tires.—If an automobile is to be laid up for a long time, say for the winter, it is advisable to remove the tires and inner tubes from the rims. The casings should then be thoroughly cleaned and carefully examined both inside and outside, and all needed repairs made at a properly equipped tire-repair establishment, unless, of course, the operator has the facilities and is capable of making the repairs himself. After removing all rust and dents, the rims should be painted. After the paint has dried, the tires may be replaced on the rims and slightly inflated. The weight should be taken off the tires by placing four blocks or jacks under the axles; also, the place in which the machine is stored should be dry and not subject to extremes of temperature.

If a machine must be stored in a damp or a very hot or very cold place for a long time, it is advisable to remove all tires to a dry place that has a fairly even temperature. The tubes and cases may be wrapped separately and stored in some cool, dark, dry place.

The greatest enemies of tires and tubes in storage are intense light, exposure to heat in excess of 75° F., and dampness. Guarding against these by selecting a proper place for storage will obviously prolong the life of the tires.

14. Miscellaneous Suggestions.—Aside from the various causes just given, there are several other causes that may produce a rapid wear of tires. Permitting tires to stand on an oil-soaked floor will cause the rubber to deteriorate rapidly, because oil has the effect of rotting rubber. Letting a car stand for months unused on inflated tires will stretch the fabric of the tires locally; the car should be placed on props when laid up. Allowing the tires to come in contact with some part of the car when running results in a rapid wearing away of the tread. Such contact may be caused by the end of a bumper, bolts extending underneath a bent fender, speedometer connections, etc.

Tires carried on the car as spares should be well covered to exclude light, heat, and dampness. It is a good practice to change the tires occasionally, placing the spare in service on

the car, and carrying one of the tires which has been in use on the extra rim as a spare.

After the tires have been run for some time, it is a good plan to reverse them, placing the right tire on the left side, and vice versa, so as to bring the worn part on the side nearest the car. The greater part of the tire wear comes on the side farthest from the car. It is advisable, also, to interchange the front and the rear tires when the rear tires begin to show wear.

Greater care should be observed when driving in wet weather than in dry weather. Rubber, when wet, will be cut by objects that it would resist when dry. This fact is recognized by tire repairmen, who make a habit of wetting the cutting knife before using it on rubber.

Makeshift repairs and neglect are other causes of the early

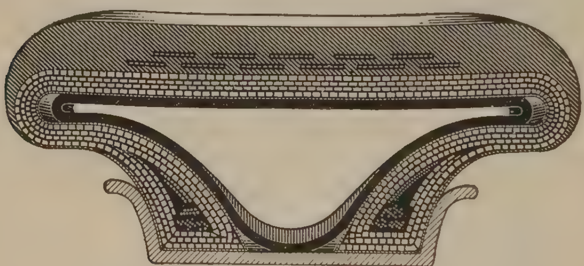


FIG. 11

destruction of tires. However small the injury, it should have prompt attention when discovered, as serious damage often results from small injuries that seem very insignificant at the beginning. As soon as possible afterwards, a permanent repair should be made at a tire service station.

CAUSES OF TUBE FAILURE

15. Underinflation.—The effect produced on an inner tube by running on a flat tire is clearly shown in Fig. 11. The tube is pinched just above the rim flanges by the side walls of the casing. The result is the cutting through of the tube in several places, and if the car is run for any considerable distance, the tube may be torn to pieces.

16. Pinching.—If proper care is not exercised in putting a tire in place, the inner tube is liable to become pinched, and hence injured. This may happen in the manner shown in Fig. 12, where a part of the inner tube is shown caught under the edge of the tire on the side that is on the rim. This condition may occur when the shoe and the inner tube are put together before placing them on the wheel rim; or, it may be the result of improper handling of the tire tools, especially the prodders, by means of which the tube may be pushed under the shoe. It is not likely to occur, however, if enough air is pumped into the tube to distend its walls before it is placed in the casing. The operator should always pass his hand around the inner tube after it has been inserted and is slightly inflated, in order to straighten it out before putting the second bead of the tire shoe in place.

Fig. 12

Also, a tube may be pinched by a rupture in the casing. When two or more of the layers of the fabric are broken, the air pressure forces the tube between the edges of the break, and the tube is soon cut through at this point. When a tube is injured in this manner, its general condition is not materially affected and it can usually be repaired in a satisfactory manner. When a tube is found with a small cut on its surface, the casing should be examined for a fabric injury.

Fig. 13

17. Chafing.—Chafing of the inner tube is a frequent source of tire trouble. The best, and probably the only way to prevent a tube from chafing is to use a small quantity of some

such substance as talcum powder, French chalk, graphite, or powdered soapstone. If no powdered lubricant is used, the tube may stick to the casing and be torn in removing, or it may wear through from chafing against the inner walls of the casing. An inner tube that was worn through from chafing is shown in Fig. 13. An excess of lubricating material is to be avoided, it being sufficient to dust the tube well all around with the powder before inserting it into the casing. If too much is dumped into the casing the powder will collect at certain points, and chafe and burn the strength out of the tube. The tube should never be inserted when wet. Fig. 14 shows a tube that was tested in water and fitted to the casing while wet. Powdered talc was thrown into the casing, with the result that dough-like lumps were formed, which hardened when the car was run, and produced the effect shown in the illustration.

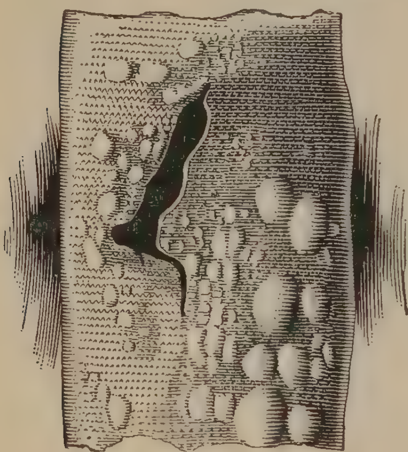


Fig. 14

An inner tube should fit the shoe properly; under no condition should it be too large. On the valve stem, the nut that holds the spring clip firmly in place, must be kept tight to prevent movement of the tube in the direction of the casing. When a tire is removed, it should be cleaned of dirt, grit, flakes from rusty rims, or other sharp particles that might increase the chafing of the tube or even puncture it. Slow leaks can often be traced to such sources.

18. Tire Flaps.—In inserting a tire flap, care must be taken to prevent its being pinched between the casing and the rim. The result of allowing a flap to extend out between the rim and the bead is an improper seating of the casing, usually

followed by a break in the casing just above the bead, the break closely resembling a rim cut. Flaps must be of the correct width for the casings in which they are to be used, as straight-side cases require wider flaps than quick-detachable clincher cases, and when inserted in the case, must not pinch the tube. If either end of the flap, through carelessness, is not anchored to the valve stem, it will work around between the tube and the casing, and eventually will cause serious injury to one or the other, or both. The proper method of applying a tire flap is shown in Fig. 15.

It is not customary to use flaps with clincher rims, because

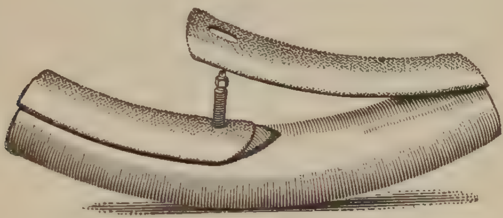


FIG. 15

of the great difficulty in stretching the case on the rim and still keeping the flap in place.

Flaps that are wet, wrinkled, chafed, or damaged in any way, should not be used. The price of a new flap is so small as not to warrant taking any chances of injury to the tube or casing by using damaged ones.

19. Carrying the Tube.—Unless an inner tube is properly protected when not in use, it will soon become unfit for service.

In order to carry a tube so that it will not be abraded and cut, it should be fully deflated and then closely folded or rolled and put into a casing, or bag. A tube can be deflated by removing the valve insides, rolling up the tube, and replacing the valve insides after deflation is completed. The successive steps of folding a tire into a bundle are illustrated in Fig. 16. It is best to cover the valve stem with an ordinary rubber

finger cap, or with a cap of some other material, such as chamois skin or cloth. Two of the views of the illustration show the valve stem covered in this manner. After the tube is folded properly, it should be dusted with talc or soapstone,

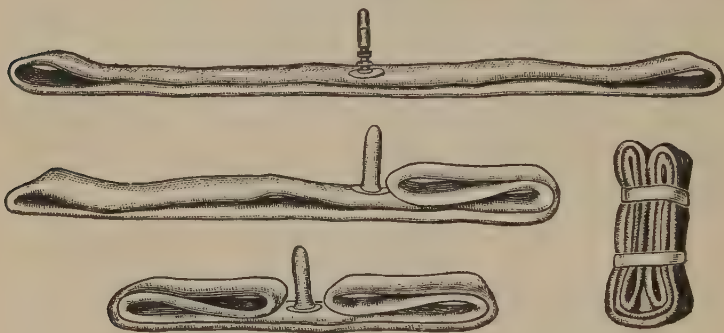


FIG. 16

and placed in an oilcloth bag. The tube should by no means be carried loose among tools, nor should it be placed where oil or gasoline can get on it.

MANIPULATION AND REPAIR OF TIRES

CLINCHER TIRES

20. Removing the Inner Tube.—One of the most important things to bear in mind when removing or replacing a tire is that the inner tube must be handled with great care. This tube is made of rubber without any strengthening fabric, and may therefore be easily punctured, cut, or torn either by the tools used or by some of the parts that attach the outer shoe to the rim of the wheel. Care must also be taken that the inner tube is not left pinched between the air valve and the outer shoe of the tire, or between the different parts of the outer shoe. The tools used for removing and replacing should never have sharp edges or corners, because they will be liable to injure both the inner tube and the shoe.

The ordinary clincher tire used on a solid rim probably requires more skill and care for its handling than any other form of tire. This type of tire is still being used on a large number of old cars and on some new smaller cars, notably the Ford Model T; hence, the method of handling it will be given somewhat in detail.

When demountable-clincher rims are used on the car, the instructions here given can be applied, the rim and tire being laid flat on the ground or floor while the work is done.

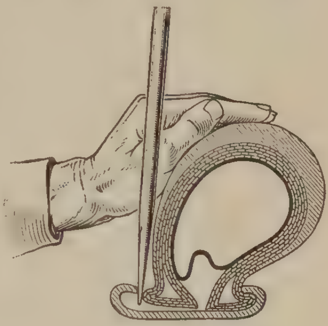


FIG. 17

21. In order to remove a tire, the wheel is first jacked up so as to relieve the tire of its load; and the tire is deflated if deflation has not already occurred, either by pressing inwards on the small valve stem that appears in the middle of the valve, or preferably by removing the valve insides.

Next, the large nut is unscrewed from the large tubular stem of the valve, and the stem is pushed in through the wheel rim. If the stem sticks in the rim, it can be forced in by pressing with a piece of wood against the valve stem. After this is done, the thin point of one of the tire prodders is inserted between the tire and one edge of the rim, as illustrated in Fig. 17, and the tire is pushed over with the hand or foot. In case no tire prodder is at hand, the tire can be loosened by placing a rounded block of wood against the side of the shoe and striking the block with a hammer.

FIG. 18

Next, both prodders are inserted about 1 foot apart under the bead of the tire on the side of the wheel opposite the valve of the inner tube and the handles of the tools are brought toward the hub of the wheel so as to pry the bead out of the rim, as shown in Fig. 18, the tools being moved nearer together if necessary. In case the tire is very stiff, one of the tools can be held by one's knee or foot, so as to keep the bead out, and the other tool worked along by hand away from the first tool until enough of the bead is removed to remain out without being held. The remainder of the bead can then be worked off with one of the tools or by hand.

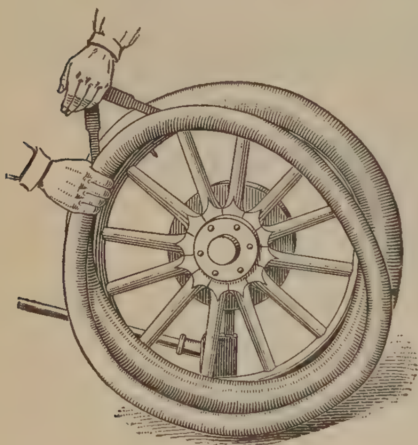


Fig. 19

After one side of the tire is removed from the rim, the edge of the tire is grasped with one hand at the point farthest from the valve stem of the inner tube, and the tire is pulled out from the rim far enough to insert the other hand to pull out the inner tube. The inner tube should be removed carefully to prevent injury to it. After all the inner tube except the portion just at the valve stem has been removed, the two tire prodders can be inserted as far as possible under the shoe, one tool on each side of the valve stem and between the casing and the inner tube. The outer ends or handles of the tools can then be brought together as in Fig. 19, and raised with one hand so as to lift the tire while the valve stem is removed from the rim with the other hand.

22. If the tube leaks, the point of leakage can usually be detected by partly inflating the tube and then immersing it in water. Bubbles will rise from the puncture and the hole can usually be located. In order that it may be found again

when the tube is deflated, it is well to mark around the hole with a pencil or piece of chalk. As much of the tube should be immersed at a time as the size of the water container will permit, and the tube should be turned until all has been under the water.

23. Removing a Casing From Rim.—If the casing, or shoe, of a clincher tire is to be completely removed, the inside bead is worked over the outside flange of the rim in the same manner as was done in the case of the outside bead. After the bead is started over the rim, the entire casing can be pulled off with little difficulty.

Fig. 20

24. Inserting an Inner Tube.—To insert an inner tube, the shoe is first lifted at the opening in the rim through which the air valve passes in the same manner that it was lifted to remove the valve of the old tube. The valve of the new tube is inserted in the hole through the rim, and the remainder of the tube is worked on by hand, care being taken not to twist it. As soon as the inner tube has been put in the shoe, it should be inflated slightly, so that it will not be pinched under the bead or the valve stem. The outer bead is then forced over the flange of the rim.

DEMOUNTABLE RIMS

25. Removing the Rim From the Wheel.—The method of removing the rim from the wheel consists of loosening a number of nuts and clamps with a wrench provided for that purpose in the tool equipment of the car. The method of loosening these nuts and clamps is shown in Fig. 20. The clamp nuts *a* are unscrewed by the brace-like socket wrench in the hands of the operator, and the clamps *b* are either removed entirely, or slipped back so as to clear the rim. The wheel is turned so that the tire valve is at the top, and the rim is swung out from the bottom. The rim is then lifted off the wheel, care being taken not to injure the valve stem while doing so.

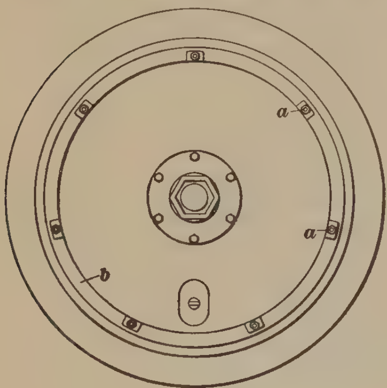


Fig. 21

Some disk wheels with demountable rims have a bolted-on ring instead of clamps to hold the removable rim in place. Such a wheel is shown in Fig. 21. The removing of the nuts *a* from the bolts which run through the felloe releases the locking ring *b*, which allows the rim to slide easily off the felloe.

Fig. 22

26. Removing Tire From Rim.—The method of removing a clincher tire from a

demountable rim of which the clincher rings are a fixed part is practically the same as the method already described for removing such a tire from a wheel.

The method of removing straight-side tires from demountable rims varies with different types of rims, but the process described in the following articles applies in a general way to most of the types in common use.

After the rim and its tire have been removed from the wheel, they are laid flat on the ground, and the cam lock *a*, Fig. 22, is disengaged by pushing it to the position shown, with a screwdriver. The rim lock *b* is freed from its slot by inserting a screwdriver back of it and forcing it away from the tire. The screwdriver is then inserted between the tire and the rim, and pressure is exerted on the handle until the end of the rim is raised, as shown. After the end of the rim is free from the tire, the rim can be pulled loose all around by grasping it as shown in Fig. 23. If the rim sticks firmly to the tire, it is probably because the tire has been on for a long time and has rusted in place. In this event, a tire tool or a blunt screwdriver should be inserted between the tire and the rim near the loose end of the rim, and the rim pried away from the tire all the way around, or until sufficient leverage is obtained to permit of pulling the rim from the tire. If this is necessary, care must be exercised to prevent injuring the inner tube.

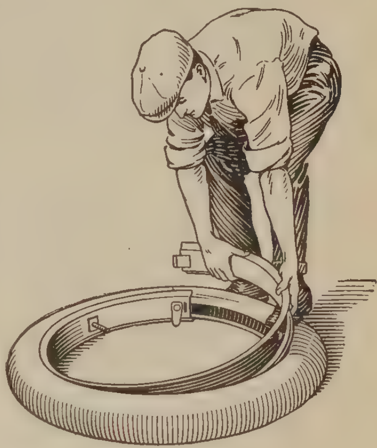


Fig. 23

27. Remounting Tire on Rim.—After the tire has been dusted with powdered chalk, the tube inserted, and the tire flap placed in position, the tire is laid on the floor or ground,

and the valve stem is inserted in its hole in the rim. By use of a screwdriver or a tire tool, the tire is forced down over the rim as shown in Fig. 24. When all the tire is in place except possibly at one end of the rim, this end can be forced into position by means of the foot, as shown in Fig. 25. When the tire is on the rim all around, the ends will still overlap. To force the loose end into place and to spring the cam lock back into its slot, a screwdriver is inserted between the two ends of the rim, as illustrated in Fig. 26, and used as a lever.

Fig. 24

28. Remounting Rim on Wheel.—In mounting the rim on the wheel, the wheel is turned so that the valve-stem opening in the felloe is at the top. The valve stem is then inserted, and the lower part of the rim is forced into place with the foot. The clamps are then drawn up gradually, those on opposite sides of the wheel being tightened alternately until all are tightened fully. The alternation in tightening is important, for if the clamps are fully tightened in regular order around the wheel, the rim may be warped slightly out of line so that the last one or two nuts cannot be drawn up properly.

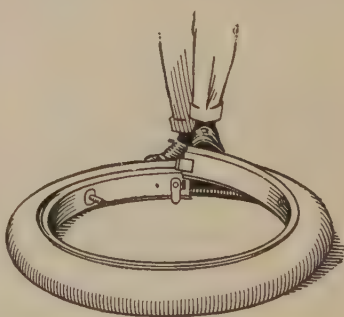


Fig. 25

29. Split-Rim Tire Tools.—In garages, or service stations where very much tire changing is carried on, the work can usually be done with the expenditure of less time and labor

by using a rim tool. The first cost of adding one of these tools to the garage equipment will soon be compensated for by the time saved. There are several makes of split-rim tools on the market, but those illustrated in Figs. 27 and 28 will serve to show the principle on which they operate.

FIG. 26

The tool shown in Fig. 27 is manufactured by the Trexler Company, Philadelphia, Pa., and is shown in the position for removing the rim. It consists of a stationary body *a* one end of which carries a perch *b* that fits under the rim, and a hook *c* that fits over it. A sliding member *d* works in the body *a* and is operated by a handle *e* and a ratchet. This member also has a perch and a hook, but the position of these is reversed in relation to those on the arm *a*. To remove a rim, the tool is applied as shown in the illustration, the ratchet is properly set, and the movement of the handle bends the rim inward until it can be easily removed. To replace the rim, it is necessary only to change the pawl acting on the ratchet, which causes the rim to expand when the handle is moved.

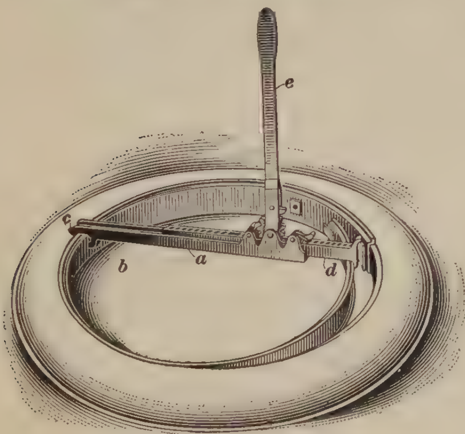


FIG. 27

30. The split-rim tool shown in Fig. 28 is manufactured by the Marquette Manufacturing Co., St. Paul, Minn. It consists of a stationary member *a*, which may be bolted to a bench or stand, if desired, and a movable member *b*. The position of the movable member is controlled by the screw *c* and the handle *d*. Turning the handle in one direction causes the member *b* to move toward the stationary member *a*, which is the action in removing the rim, and turning it in the opposite direction moves the member *b* away from member *a* and expands the rim. In the position shown, the tool is expanding the rim, the latches *e*, which hook into the rim when the

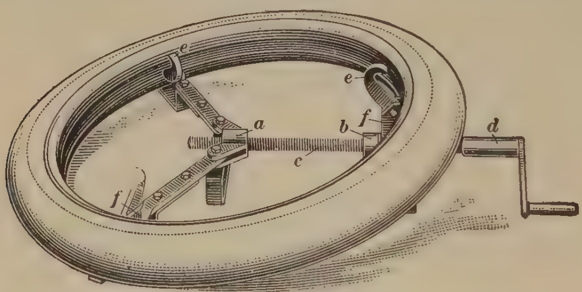


FIG. 28

rim is being removed, are thrown back, and the shoulders *f* are against the rim.

In large garages, or tire service stations where sufficient tire business is carried on to warrant the cost, it is a good plan to install a stationary tire tool, different types of which are on the market. Such a machine greatly simplifies the work of changing tires, and is a valuable addition to the service station equipment.

The portable tools just described are useful on the road as well as in the shop, and can be folded up so as to be easily disposed of in the car.

QUICK-DETACHABLE DEMOUNTABLE RIMS

31. Removing Tire From Rim.—To remove a tire from a quick-detachable demountable rim, the rim may either be taken off the wheel, or the tire removed directly from the wheel, without disturbing the rim. In either case the method of removing the tire from the rim is the same. The first step in removing the tire is to insert a screwdriver; or other similar tool, between the side ring *a*, Fig. 29, and the locking ring *b*, and to pry downward so as to produce an opening between the two rings. A coin, nut, or other convenient piece of metal is dropped into this opening so that the locking ring will be free from the side ring when the screwdriver is withdrawn. The screwdriver is then in-

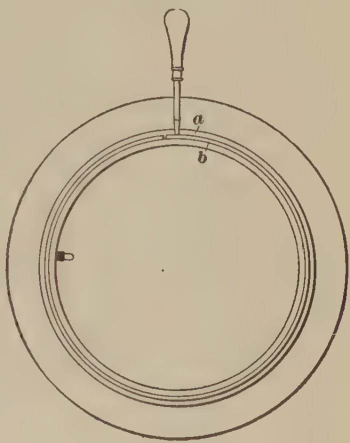


Fig. 29

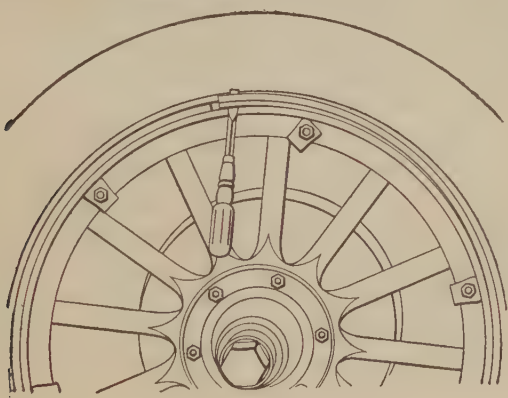


Fig. 30

serted in the slot near the end of the locking ring and pried downward until the ring is forced out of its groove, as shown in

Fig. 30, after which the ring can be removed with the hands. After the locking ring has been sprung out of its groove, the side ring is taken off, and the tire removed by swinging it out sidewise, commencing on the side of the wheel opposite the valve and lifting it at the valve so as not to injure the valve stem.

32. Replacing Tire on Rim.—A quick-detachable tire is replaced on the rim by simply reversing the operations necessary for its removal, care being taken not to damage the valve stem or the inner tube.

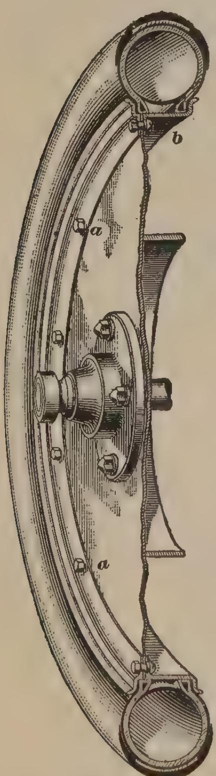


FIG. 31

A quick-detachable demountable rim together with the tire is demounted from or remounted on the wheel in the same manner as described for the regular demountable rims.

DEMOUNTABLE WHEELS

33. It is the common practice on cars equipped with wire or disk wheels to carry one or more extra wheels on which a tire is already in place and inflated; then in case of tire trouble the new wheel is substituted. In the case of wire wheels, all that is usually necessary to change wheels is to jack up the wheel, remove the hub cap, slip off the wheel, place a spare wheel on the hub, and screw the hub cap back in place. The only tool needed to make the change is a hub-cap wrench, which is a part of the regular tool equipment of the car.

With some disk wheels, a wheel change is easily effected by jacking up the wheel, unscrewing the hub flange nuts, removing the hub flange, and then slipping the wheel off the hub.

A spare wheel is then placed on the hub, the flange is replaced, and the flange bolts are screwed firmly in place. A wheel of this type is shown in Fig. 31. If it is desired to remove the tire from the wheel, the rim bolts *a* are unscrewed, which frees the moveable ring *b*, and allows it to fall away from the disk. This ring forms the outer rim flange and, when removed, allows the tire to be pulled off the rim. To replace the tire, these operations are simply reversed.

INNER-TUBE REPAIRS

34. Small punctures and breaks in inner tubes can be repaired on the road by means of patches, but when time is available, it is much better to have the injured part vulcanized, thus making a permanent repair. Inner tube patches can be purchased ready cut in various diameters, or they can be purchased in sheets and cut as desired.

35. Cement Patches.—One type of cement patch largely used has one side of raw, or uncured rubber, protected by a cloth facing, and requires no cement other than that applied to the surface of the part being repaired. To apply the patch, the section of the tube around the injury is first roughened by means of sand paper or emery cloth, and then cleaned with clean gasoline and allowed to dry. After the tube is cleaned, a good rubber cement, sold for this purpose, is spread thinly for about an inch around the opening, and allowed to dry until it becomes *tacky*, or sticky, when touched with a finger. Another thin coat is then applied and allowed to dry to the same extent. A patch large enough to extend an inch or more beyond the hole is then selected, or a piece of the desired size is cut from the sheet, the protecting cloth is removed from the uncured side, and the patch is applied directly to the injured spot with the uncured or raw side of the rubber next to the tube. With some kinds of cement patches, the user is instructed to moisten the uncured face with gasoline after the protecting cover is removed, and such instruction should be observed before applying the patch. In applying the patch, care must be

taken to exclude all air from under it, as an air bubble might cause a leak, and pressure should be applied for a few minutes to give the patch a chance to become *set*. It is a good practice to press the patched portion of the tube against a warm spot on the radiator of the car, as this will facilitate the drying and effect a firm union between the patch and the tube.

36. No-Cement Patches.—A quick repair of a puncture of an inner tube can be made by means of the *no-cement patch*, or the *self-cementing patch*, which can be applied to the tube without either cement or acid. When using a patch of this kind, it is necessary only to buff the tube around the puncture with emery cloth and clean with gasoline. The muslin facing is then removed from the patch and the uncured gum side moistened with gasoline, after which the patch may be applied to the tube. It should be pressed down firmly and kept under a weight for a few minutes, when the tube can again be put in service. When in use, the unvulcanized surface of the patch is cured to the tube by the heat generated in the tire, and becomes a part of the tube. Various sizes of no-cement patches can be obtained and the one best suited for any particular puncture should be selected.

37. When an inner tube is punctured and it is possible to locate the puncture before the tube is completely removed from the shoe, a good plan is to mark the tube where it is punctured and then inspect the shoe in the neighborhood corresponding to the puncture in the tube for the purpose of locating a tack or nail that may have caused the trouble. This inspection can be made by rubbing the hand around the inside of the shoe. If this is not done, another tube that is put into the shoe will be immediately punctured by the tack or nail still remaining in the shoe. If a nail or a piece of wire is found sticking through the casing for some distance, the tube should be inspected for two holes, opposite each other, caused by the nail piercing both sides of the tube.

38. Splicing Inner Tubes.—Sometimes an inner tube will become so badly worn or ruptured at some point that it is

impossible to repair it in the usual manner by means of patches and cement. Such a case is shown in Fig. 32, and a repair can be made by removing the damaged portion of the tube included between the dotted lines and putting in a new section by means

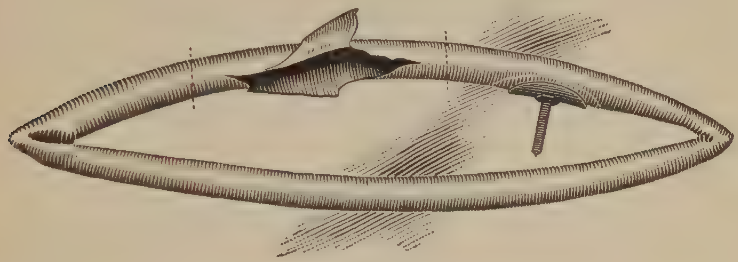


FIG. 32

of splicing; the new section must be about 5 inches longer than the old one to allow for a $2\frac{1}{2}$ inch splice at each end. The process of making a splice is more difficult than that of making an ordinary repair and, hence, requires the services of an experienced repairman.

Splices are of two kinds, namely, the vulcanized splice

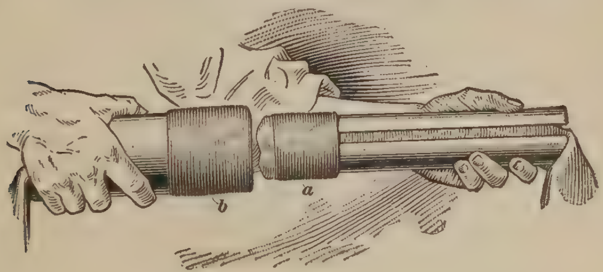


FIG. 33

and the cold, or acid-cured, splice. The former is made only in the vulcanizing plants where the necessary facilities are at hand, but the latter, or acid-cured, splice can be made with a few tools by a repairman. The ends of the tube are tapered with a sharp knife and the inside surface buffed for a distance of about $2\frac{1}{2}$ inches from the ends by means of a wire brush. The

ends of the section to be spliced in must be buffed in the same manner on the outside.

After the ends of the tube and the sections are properly leveled and buffed, one end of the tube is passed through the smaller of two split cylinders, and turned back about 5 inches; it is then doubled forwards for about $2\frac{1}{2}$ inches, making a double lap on the end of the small splicing cylinder, as shown at *a*, Fig. 33, with the outside surface of the tube facing out. One end of the new section is put through the larger splicing cylinder, and is doubled back about $2\frac{1}{2}$ inches on the cylinder as shown at *b*, making the inner surface come on the outside. Two coats of acid vulcanizing cement are then applied to the exposed surfaces on the cylinders, one coat being given time to dry to the proper consistency before the next one is applied. Ten minutes is sufficient for the first coat, but the second one requires a longer time, or about 30 or 40 minutes. After making sure that the tube is not twisted, the two ends are brought close together, as shown in Fig. 33, and both cemented surfaces are quickly covered with acid solution applied with a wide soft brush. The two ends are brought together, and the end of the section on the large cylinder is folded over on to the end of the tube on the small cylinder, the transfer taking place as quickly as possible. No more than 8 seconds must elapse between the applying of the acid and the joining of the two ends. The spliced ends should be wrapped tightly with sections of inner tube, as shown in Fig. 34, and left for from a half hour to an hour in order for a solid union to form.

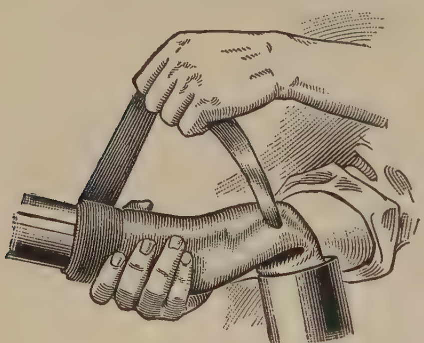


Fig. 34

39. The entire operation must be repeated at the other end of the section, after which the tube can be removed through

the slots in the cylinders. If the splice doesn't cure well, it is an indication that the junction of the two ends was not made quickly enough after the application of the acid solution.

If the acid solution cannot be purchased ready prepared, it can be obtained from wholesale drug houses through local druggists, the formula being 1.7 fluid ounces sulphur monochloride (S_2Cl_2) to 1 gallon carbon tetrachloride (CCl_4).

CASING REPAIRS

40. Inside Blow-Out Patches.—When a blow out occurs, or when the casing is cut through, and no spare tire is available, the car should not be run any farther until the injured section has been repaired. In case of emergency, a temporary repair can be made on the road by the use of a blow-out patch, but at the earliest opportunity the tire should be taken to the vulcanizer for a permanent repair. If the tire is too old to warrant the expense of vulcanization, a repair that will probably last as long as the remainder of the tire, can be made by means of the patch shown in Fig. 35. This patch is made up of several plies of fabric vulcanized together with rubber, and is shaped to fit the different-sized casings. The patch is made in such a manner that the outside layer of fabric is smaller than the inside layer, so that the patch tapers down to a thin edge, thus making a smooth joint with the inside of the casing which will not damage the inner tube.

FIG. 35

To apply the patch shown in Fig. 35, the casing must be dry. The inside is cleaned all around the break with gasoline for a space a little larger than that to be occupied by the patch, after which, a coat of tire cement is spread over the cleaned surface. When this has had time to dry to a tacky condition, another coat of cement is applied, and allowed to dry. The

patch is treated in the same manner as the casing, and when both are sufficiently dried, the patch is inserted in the casing, and pressed down firmly and smoothly. Sufficient time must be allowed for the patch to become set before placing the tire in service. Some patches, similar to the one shown, have an unvulcanized rubber face, and after the removal of the muslin covering, are applied to the injured section of the tire. The heat generated in the tire is then depended on to vulcanize the patch permanently in place.

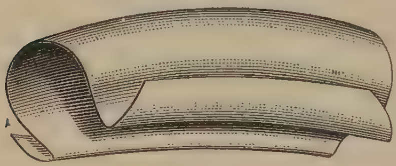


Fig. 36

41. A temporary roadside repair can be made in an emergency by means of the patch shown in Fig. 36. This patch is built up of several layers of fabric vulcanized together by rubber, and the bottom layer has extensions or flaps which go under the beads, and hold the patch firmly in place. This patch should be applied without cement except in cases of old tires, when it can be applied permanently in the same manner as described in connection with the patch shown in Fig. 35.

42. A form of inside patch intended for use in repairing cord tires is shown in Fig. 37. Because of the cord construction, a cut in a cord tire will not spread as it would in the case of a fabric tire, so a repair made with this patch will last a long time. If the tire is otherwise in good shape, and is worth the expense, vulcanization is the most practical repair, however. The patch consists of several layers of cords embedded in rubber, and cured in the same manner as the cord tire itself, and is faced on one side with vulcanized rubber protected by a muslin cover.

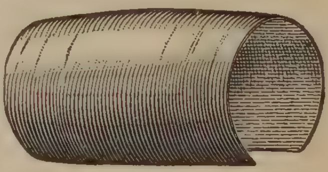


Fig. 37

The patch is applied by cleaning around the break with gasoline, and covering the inner surface of the casing with two

applications of cement, and each coat is allowed to dry until it becomes tacky. The cloth protector is then removed from the inside of the patch, and the side thus exposed is applied over the injury, without cement, and pressed firmly into place. If any of the patch projects beyond the bead, it should be trimmed off flush with the inner edge of the bead.

Fig. 38

43. Outside Protectors. After the casing has been repaired on the inside, thus protecting the inner tube, it is advisable to put a protector patch on the outside of the casing, to keep dirt and moisture out of the break, and prevent the casing tearing further before a permanent repair can be effected. Small through cuts can be plugged temporarily with a form of tire dough, the use of which will be explained further on.

Outer-casing protectors are held in place in different ways. The one shown in Fig. 38 is provided with eyelets and a rawhide lace, and is laced in place. In applying this patch, at least one turn of the lace should be taken around a wheel spoke to prevent the patch from creeping. The patch shown in Fig. 39 has buckles and straps, and is fastened by giving the straps a turn around the spokes and then buckling them to the short protector attachments. Other patches are held in place by clasps, hooks, or similar metal fastenings. In some cases, the patch is made of mineral chrome leather, often reinforced by metal disk inserts, and in other cases, it is made of rubber and woven fabric in a manner somewhat similar to the tire shoe.

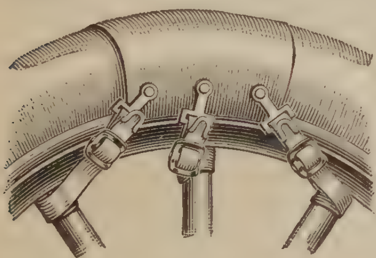


Fig. 39

44. Cuts and Blisters.—Cuts of any kind, as well as blisters, on the tire shoe should be repaired at the earliest

possible moment. If the cut is left open, a sand blister, also called a *mud boil*, is almost certain to form. Although it is hardly possible to make a durable repair of a cut while on the road, it can be remedied to some extent. If the cut is small, it can be temporarily repaired by filling it with rubber dough. If the cut is rather large and deep, it may be protected by forcing a piece of rubber patch into it and then cementing this patch in place. After the cement has set, the patch can be trimmed down smooth with the surface of the tire, and the tire then wrapped with tire tape. Neither repair is permanent, and hence a vulcanized repair should be made as soon as possible.

If the cut in the casing is comparatively small and deep, as when made by a small piece of glass, it should be probed with the blunt end of some small instrument as soon as it is discovered, in order to ascertain whether or not the glass still remains in it. Frequently, a small piece of glass will embed itself in the rubber near the surface of the tread as the wheel passes over it, and then gradually work its way through the shoe and puncture the inner tube as the wheel travels along the road. The glass should be removed immediately, and the cut filled with rubber dough. This dough is a soft, pliable, self-curing gum which dries on contact with air, and is so elastic that it stretches with the rubber of the tread after being applied. It is sold under various trade names, such as *cure cut*, *tire dough*, *tire putty*, *plastic*, etc.

45. To use the tire dough, the cut is first cleaned of all dirt and grit, and then washed out with clean gasoline, applied with a small piece of cloth on a thin stick or small tool. The interior of the hole is then covered with a layer of good patching cement, and the cement is spread for about a half inch around the cut on the outside of the casing. When this coat has dried sufficiently, that is, when it becomes tacky, another coat is applied, and while this coat is drying, the tire dough should be made ready to apply. A piece of the dough about twice as large as the hole to be filled is taken from the can and kneaded with the palms of the hands until it changes from a sticky mass to a ball. If the second coat of cement is dry

enough, the wad of tire dough is worked into the opening, and rammed by a small screwdriver, or other similar tool, into every crevice of the cut. Enough filler should be used so that it will extend well above the surface of the casing when the hole is filled up, as it will shrink in drying. The repaired tire should be allowed to stand long enough for the filler to cure, several hours, if possible, and then the excess should be trimmed off flush with the surface of the casing with a sharp knife. The knife will cut rubber easier, if it is wet before being used.

If the dough is not sufficiently plastic to permit of kneading with the hands when it is first removed from the can, a little gasoline may be poured on it. The gasoline will soften the rubber enough so that it can be worked satisfactorily, but will soon evaporate and allow the compound to thicken again when applied.

The method of repair just described is applicable to new cuts, but it is of little value for old cuts. Expert advice should always be sought in connection with old cuts, as it is possible that tread separation or fabric rotting has set in, and no repair that will not improve these conditions, is of any value. They will simply grow worse with use until the tire will finally have to be discarded, though with the proper attention at first, its service might have been extended thousands of miles.

CARE OF RIMS

46. Cleaning Rim.—If a tire that has been in place for some time is removed, it will be found that the rim is more or less rusted. The rim should therefore be cleaned and smoothed before the tire is put on again. The rust can be removed by scraping or by brushing with a wire brush. With a clincher rim, especial care must be taken to see that the clincher part of the rim, into which the shoe bead fits, is thoroughly clean. Rust collecting under the clinch may prevent the bead from going entirely into the proper position. After the rust is scraped off, the rim should be smoothed with a fine file. Emery cloth can also be used to advantage for smoothing the rim.

47. Rim Paint.—Various prepared rim paints can be bought on the market, or an excellent rim paint can be made by mixing dry flake graphite with shellac. When no other substance is available, plain shellac, stove polish, or paint containing no oil may be used. Any of these is preferable to using the uncovered rim surface, as the paint not only makes the removal of the tire easier, but protects the tire against the destructive action of rust.

48. Bent Rims.—Sometimes a rim is bent or dented by being struck by a hammer while being removed, or by coming in contact with a stone in the road; all such bends should be corrected as soon as discovered. An inward bend causes undue pressure on the side wall of the casing, while a bend outward leaves an opening for water and dirt to work in between the tire and rim.

VULCANIZATION OF AUTOMOBILE TIRES

VULCANIZING METHODS AND EQUIPMENT

VULCANIZING OF INNER TUBES AND CASINGS

DEFINITION

1. Rubber in its crude state is of little use commercially, because it is easily affected by temperature conditions. It was not until the discovery was made that crude rubber, mixed with certain ingredients and subjected to a certain degree of heat, becomes pliable and not subject to change in different temperatures, that rubber came into general commercial use. The process of heating the rubber to a temperature sufficient to make it change from either the gummy or the plastic state, as the composition may be, to the condition that is found in a new tire casing, or tube, is known as vulcanizing. In other words, in reference to tire work, **vulcanization** is the process of heating crude rubber and sulphur in combination until the mass has been brought to a state in which it is both elastic and durable.

This process is employed in both the manufacture and repair of automobile tires, but it is with repair only that the automobile owner, driver, or repairman is interested and it alone will be dealt with here.

In the repair of tires, a patch on the inner tube or the rubber reinforcement in a cut or blow-out in a casing is vulcanized in

order to make the repair a permanent part of the tire. The heat for the vulcanizing apparatus, or vulcanizer, is generally supplied by electricity, steam, or gas. The temperature to which the rubber is raised by the vulcanizer should probably never exceed 250° to 275° F.

MATERIALS

2. The materials commonly used in tire-repair work are *friction*, which is a textile product of high grade long-fiber cotton, impregnated with rubber; *cushion gum*, practically a pure gum used in casing repairs, and for vulcanizing tubes; *rebuilding fabric*, a friction material, gum treated on both sides; *bare back*, a cotton fabric frictioned on one side only; *breaker strip*, a narrow width of heavily woven elastic fabric, impregnated with rubber; *tread stock*, a rubber composition used for tread repairing, side wall repairs, and as an under cover; and *camel back*, a tread stock made thick in the middle, so that it serves the same purpose in retreading as several layers of the regular tread stock.

VULCANIZING OF INNER TUBES

3. Repair of Holes and Cuts.—The first and most important step in the preparation of an inner tube for vulcanizing is to clean it thoroughly in the vicinity of the injury with clean gasoline. If the hole is very small, it can be repaired more easily by enlarging it a little. The tube is then buffed or roughened for at least an inch all around the hole by a rasp, piece of coarse sandpaper, or emery cloth, and then is wiped clean with a cloth moistened with gasoline. When the gasoline has entirely evaporated, making sure that no oily residue remains, vulcanizing cement is spread thinly around the hole for an inch or so, and on the edges of the hole. When this coat has dried for ten or fifteen minutes, a second coat is applied and allowed to dry thoroughly. Ordinary rubber cement is worthless for making vulcanized repairs; regular vulcanizing cement must be used. The hole is filled with raw rubber, and

a small piece of the rubber is placed over the puncture so as to extend about a half inch all around it. A piece of waxed paper is placed over the section to be vulcanized to prevent its sticking to the vulcanizer, and the tube is then vulcanized for 15 minutes at 265 degrees.

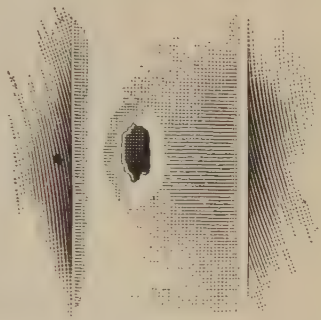


FIG. 1

4. When a larger hole or cut is to be repaired, the edges of the hole are trimmed off, and the tube is buffed or roughened by sand paper on the inside and outside for a space of at least an inch around the opening. The surface is washed inside and outside with gasoline on a small cloth, and two coats of vulcanizing cement are applied on the inner surface of the tube around the hole; each coat being permitted to dry separately. The tube is then ready for the new rubber, and is shown in its prepared state in Fig. 1.

A piece of one-side-cured gum is cut large enough to extend $\frac{1}{2}$ inch beyond the hole, in each direction, and inserted on the

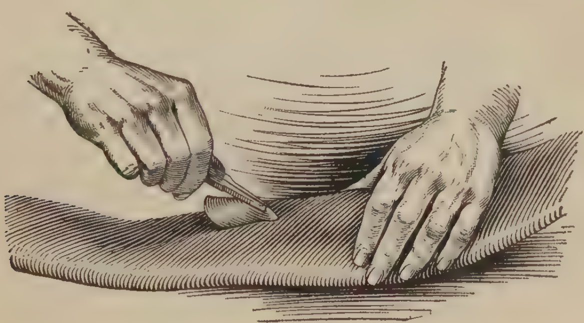


FIG. 2

inside of the tube with the uncured or raw side next to the injury. This patch can be inserted by folding it and setting it

in place by long-nosed pliers, as shown in Fig. 2, and when in place must be pressed down firmly so as to be in intimate contact with the tube at all points. The cured side of the patch is toward the opposite side of the tube and prevents the patch and the tube from sticking together. The cavity being repaired is filled up with small strips of raw gum, worked in thoroughly until it sticks to the edges of the hole all around. The gum is then rolled lengthwise and crosswise with a tool having a wheel with sharp teeth as shown in Fig. 3, known as a *stitcher*, which prevents the formation of air bubbles, and insures a thorough union of the new repair gum and the tube. The repair is covered with waxed paper and placed on the vulcanizer, and is then cured for 12 minutes at 60 pounds steam pressure (if steam is used) or 18 minutes at 40 pounds steam pressure.

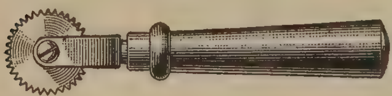


FIG. 3

Holes or tears of large size can be repaired in this way, and the finished job, when properly done, will be as strong as the original tube. If the injured section is so large as to render vulcanizing impossible in one operation, the repair should be prepared all at once, and then vulcanized at two or more settings, as the case may require, until the entire repair is cured.

5. **Splicing a Tube.**—When a spliced joint in a tube is to be made, the damaged part is cut out and a new section substituted. The ends of the tube from which the damaged section has been removed, are tapered with a sharp knife, and the inside surface buffed for a distance of about $2\frac{1}{2}$ inches from the ends by means of a wire brush. The ends of the section to be spliced in must be buffed in the same manner on the outside. After the ends of the tube and the section are properly buffed and beveled, one end of the tube is passed through the smaller of two split cylinders, and turned back about 5 inches; it is then doubled forwards for about $2\frac{1}{2}$ inches, making a double lap on the end of the small splicing cylinder, as shown at *a*, Fig. 4, with the outside surface of the tube facing out. One end of the new section is put through the larger splicing

cylinder, and is doubled back about $2\frac{1}{2}$ inches on the cylinder, as shown at *b*, making the inner surface come on the outside. Three coats of vulcanizing cement are applied to the exposed

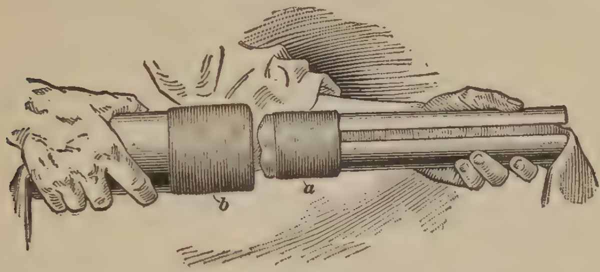


Fig. 4

surfaces, each coat being allowed to dry thoroughly before the next one is applied. The two ends are then brought together, and the large cylinder is folded over on to the end of the tube on the small cylinder. When the ends have been brought together and cemented into place, the operation is repeated on the other end of the tube. Then the tube is ready for vulcanizing, as shown in Fig. 5, three separate operations being required for each end. A block *a* is used to prevent pinching the edges of the tube *b*, and after the first section has been cured for about 20 minutes, the tube is turned one-third the way around so that a new section is in contact with the vulcanizer *c*, and is cured for 15 minutes; after which, the operation is repeated on the next one-third part of the tube.

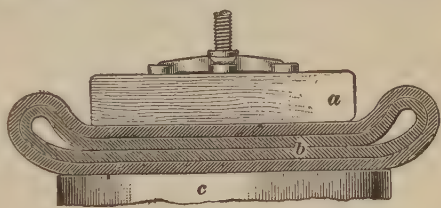


Fig. 5

6. Valve Repairs.—An injury due to a broken valve fabric can best be repaired by removing the broken fabric, when possible, filling in and vulcanizing the old valve opening in the tube, and applying a new valve patch at another point in the tube.

In making such a repair, all fittings are removed from the valve stem, and the stem is pushed back into the tube; after which the old opening can be filled up with raw gum, as described for repair of holes in inner tubes, and vulcanized.

To apply a new valve patch, a good place is selected on the tube and cleaned for a space of about $2\frac{1}{2}$ by 4 inches, and a hole about $\frac{1}{4}$ inch in diameter is cut through the center of the cleaned space. The surface of the tube is cleaned and cemented around the hole in the same manner as described for other tube patches. A diamond-shaped, or oval, piece of thin raw gum, is then cut to about 2 inches by 3 inches, a hole of the same size as that in the tube is cut in the center, and the gum is applied to the tube so that the two holes register. A piece of fabric of the same size as the gum strip and with a hole cut in its center, is placed over the first strip; after which another thin strip of raw gum about $\frac{1}{4}$ inch longer than the fabric all around, and with a hole in its center, is placed on the fabric. The hole in the center of the laminated patch is then filled with a wad of paper, and the patch is vulcanized, 40 minutes being required for a good job.

When the vulcanizing is finished, the valve stem is slid around inside the tube until its end can be forced through the hole in the valve patch, after which the nut is screwed on the valve stem and the stem forced through the hole until the base is tight against the inside of the tube.

7. When it is desired to change a valve stem without injuring the valve patch, the fittings are all removed from the stem, and the stem is pushed back through the hole into the tube. A hole is cut into the tube some distance from the valve patch and large enough for the withdrawing of the old stem and the inserting of a new one. The new stem is worked around to the hole in the valve patch and forced through, and the emergency hole is repaired as already described.

VULCANIZING OF FABRIC CASINGS

8. Methods.—Repairs of tire casings are of two kinds—the inside repair, or *wrapped method*, in which all the rebuilding is done on the inside of the tire, and the inside-and-outside repair, or *sectional method*, in which the reinforcing material is applied both inside and outside.

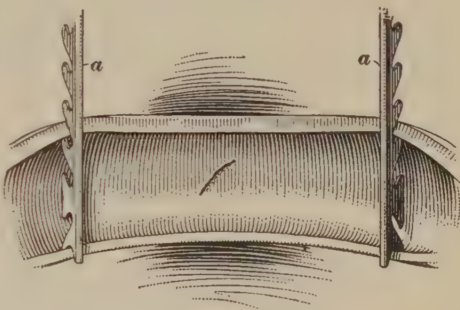


FIG. 6

9. Wrapped Method of Repairing.—For small cuts or holes, and for broken fabrics on the inside of the casing, the inside repair gives excellent results, and is usually both cheaper and quicker than the sectional repair. The exact method of repair must vary somewhat according to conditions, but the instructions here given apply to all cases, with slight modifications to cover individual requirements.

To make an inside repair, the casing is held open as shown in Fig. 6, *tire spreaders a* being used for this purpose, and the inside of the casing is washed with gasoline to soften the rubber. A hoe-shaped scraper is then used to clean off the fabric until the bare fabric is exposed at least 6 inches on each side of the hole. After the edges of the hole and the outer surface of the tire immediately around the hole have been cleaned thoroughly, a coating of vulcanizing cement is applied to the cleaned surface on the inside of the casing, and to the edges of the hole. This coat must be allowed to stand for a half hour or so before applying a second and thicker coat, which coat must be left for several hours, or until it has dried thoroughly, before applying any patching material. A piece of fabric is cut large

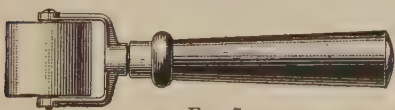


FIG. 7

enough to extend at least an inch beyond the hole in all directions. Fabric should always be cut on the bias at an angle of 45 degrees, as repairs made with fabric cut straight with the roll are very likely to become hard and to bulge. The piece of cut fabric is placed on the cemented surface over the hole and rolled smoothly into place. It is best to roll from the center toward the edges of the patch to insure intimate contact at all points, the tool shown in Fig. 7 being used for this purpose, and all air must be allowed to escape by pricking any air bubbles with a pointed instrument.

If new fabric, coated on both sides with Para rubber, is used, a new layer large enough to extend an inch and a half beyond the first patch all around, is placed on the first one, no cement or separate layer of Para rubber being necessary. Tire repairmen, however, make a practice of tearing down old casings and using the good parts of the fabric in repair work, and when such fabric is used, a thin layer of Para rubber should be placed between the layers of fabric. A third patch is then put on in the same manner, extending about $1\frac{1}{2}$ inches on all sides beyond the second one. If the tire is very large, five patches should be applied, but if not, a fourth layer, rubber-coated on one side only, large enough to extend from one inner edge of the casing to the other, and at least an inch larger on each side than the third patch, should be applied with the rubber-coated side next to the patch. If five patches are used, the fourth should be of the same material and applied in the same way as the third one, the fifth or outer patch being rubber coated only on the side nearest the tire. The method of stepping up the different patches is shown in Fig. 8.

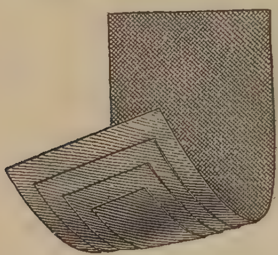


Fig. 8

When the inside of the tire is ready for vulcanizing, attention is given to the outside. The hole was treated with cement at the same time as the inner surface of the casing, so is now ready for building up. First, a piece of thin Para rubber is cut

as near the size and shape of the hole as possible, and pressed firmly in place at the bottom of the hole. The remainder of the hole is then filled with small scraps of tread stock, each piece being worked thoroughly so that it will make close contact with other pieces and the sides of the hole, no cement being required. When the hole is filled up so that it is a little higher in the center than the edges, which are flush with the old tread, the tire is ready for vulcanization.

10. Another method of making the inside repair is to remove portions of the fabric plies on the inside of the casing, and replace the removed sections with new material. The number of sections to be removed depends on the size of the tire, the usual rule being two plies from $3\frac{1}{2}$- and 4-inch tires, three plies from $4\frac{1}{2}$-inch tires, four plies from 5-inch tires, and so on. To make this repair, the inside of the casing in the vicinity of the injury is cleaned as already described, and the plies of fabric are removed in steps as shown in Fig. 9, the last or inmost section being removed at least 2 inches from the hole all around. The steps are cut so that from the lowest one around the hole each succeeding one is about $1\frac{1}{2}$ inches larger all around than the one next below it, and all edges should be beveled so as to make a good junction with the patch. A coat of vulcanizing cement is applied to the exposed surfaces and to the inner edges of the hole, and is allowed to dry for an hour or so, after which a second coat is put on and allowed to dry for several hours so that all gasoline will have time to evaporate.

Fig. 9

11. A patch is made up of the same number of plies of fabric as those cut from the casing, and with steps to correspond to the stepped-down plies of the section being repaired. A layer of *bare back*, or fabric rubber-coated on one side, of

sufficient size to reach to the toe of the bead on each side, and extend an inch or so beyond the patch underneath, is applied to the built-up patch, and the whole assembly is rolled thoroughly on a table before being placed in position in the casing. This is done to insure a firm union of the different layers, and to remove any air bubbles that might have formed under the fabric. When the patch is applied to the casing, it must be

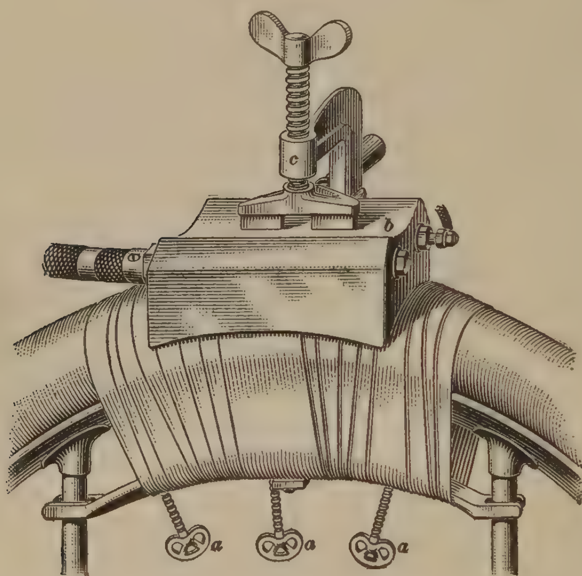


Fig. 10

rolled smoothly in place, and any air pockets underneath must be pricked with the awl.

The exterior of the tire is treated in the same way as described in connection with the former method. When the tire is ready for vulcanizing, the inside of the casing is sprinkled with soapstone and placed on the vulcanizer form. The repair is covered with wax paper and wound with binding tape, the method of applying the tape being shown in Fig. 10, and when the end of the tape is fastened with a pin, the tension screws *a* are tightened until the casing is drawn firmly into contact with the vulcanizer form. A form *b* is placed on the outside

directly over the repair and is held by the clamp *c*. Only enough pressure need be applied to the clamp to keep the form in place, as the binding tape provides the necessary pressure, and gives the repair its shape.

Heat is applied to the inside and outside at the same time by the two forms, and at the end of fifteen minutes, the clamp *c* is loosened and screws *a* tightened. For a medium-size tire, the curing should last about an hour at 40 pounds steam pressure. Smaller tires, as $3\frac{1}{2}$-inch, require less time, about 40 minutes being sufficient.

12. Inside-and-Outside Repair.—In the inside-and-outside repair, the layers of material are removed from the outside of the casing, and the edges beveled, or *skived*, in much the same manner as in the method of inside repair just described. The number of plies to be removed follows the same rule as set forth for inside repairs, the exact number, however, being a matter of judgment, based on the extent of the injury. All plies removed should be stepped down 1 inch in the direction of the circumference of the tire; a margin of $1\frac{1}{2}$ inches should be left between the last ply removed and the extreme point of injury; and the tread should be cut away or laid back $1\frac{1}{2}$ inches farther than the first ply removed. In this method of repair, the fabric sections or plies are removed down to and including the beads. This is done to make a neat job as well as to give the repair strength and firmness. When the old fabric is removed only part way down the side walls of the carcass, a sharp hinge is formed in the tire, and there is a tendency for the repair to loosen and the old fabric in the casing may break.

13. Before tearing the outside of the carcass down for a sectional repair, the inside of the tire should be buffed thoroughly. If the buffing is not done until after the fabric sections are removed, the tire will be too flimsy to allow a good job to be done.

Sectional repairs are of three types; namely, *full section*, *half section*, and *quarter section*. In a full-section repair, the fabric in the region of the injury is cut away from bead to bead, and

this method is used when there is a large blowout in such a position that it cannot be repaired by either of the other two methods. A half-section repair extends approximately half way around the casing, and is used when the injury is not too large and is located between the bead and the center of the tread. A quarter-section repair usually extends from the bead to the center of the tread, and is used in case of a rim cut or of a bead broken away from the body of the tire. In making any of these repairs, the following general instructions will apply in all cases.

After the plies of fabric have been stepped out according to the nature of the injury, the edges of the injury are cleaned of all loose fabric and beveled or skived, care being taken that the edges of the injury do not touch. All of the exposed outside surface is then buffed thoroughly at least 1 inch farther than the largest section removed, after which the tire is ready for the cement.

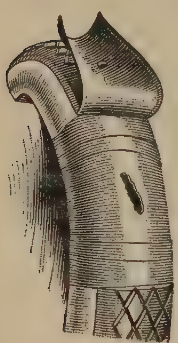


Fig. 11

Before applying the cement, the buffed surface is cleaned with a cloth moistened with gasoline. Then a thin coat of vulcanizing cement is applied and rubbed in thoroughly. When this coat has dried from 30 to 60 minutes, a coat heavier than the first is spread on, smoothed out carefully, and allowed to dry from 30 to 60 minutes. A third coat lighter than the second but slightly heavier than the first is then applied, and allowed to dry until all solvent has been evaporated, which usually requires from 3 to 5 hours. Before applying new material to the cemented surface, any dust should be removed with the cloth moistened with gasoline.

14. A full-section repair ready to be built up is shown in Fig. 11. When the tread is not badly damaged, it can be cut at one end and laid back as shown in the illustration, the cut being made at a bevel of 45 degrees so as to make a smooth joint when the tread is replaced. To build up the full section, the exposed surface of the tire is covered with a very thin

sheet of pure gum, about $\frac{1}{64}$ inch thick, to within $1\frac{1}{2}$ inches of the bead. As many plies of new fabric as those removed from the section, are now applied so as to lap the edges of the old fabric $\frac{1}{8}$ inch, except in the case of the outer ply, which should lap $\frac{3}{4}$ inch. The new fabric should be frictioned, that is, impregnated with rubber compound, and have a rubber coating on one side, the rubber-coated side being placed down. The bead strips, or chafing strips, of light-weight fabric are placed in position, being lapped 1 inch on the outside, and $1\frac{1}{2}$ inches on the inside. The side wall is replaced with one ply of tread gum $\frac{1}{16}$ inch thick, extending from about $\frac{1}{4}$ inch above the bead to about $\frac{1}{4}$ inch over the tread line. This piece must be rolled down until perfectly smooth and should be beveled at the edges so as to make a smooth junction with the remainder of the tire. A piece of cushion stock is applied at the top of the section, and the raised tread is replaced.

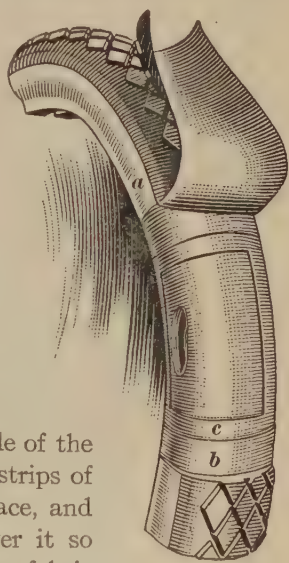


Fig. 12

No fabric is removed from the inside of the tire, but the hole is filled with small strips of cushion gum carefully kneaded into place, and a two-ply fabric patch is applied over it so as to lap over the ends of the outer fabric patch about 1 inch and extend about 1 inch beyond the ends of the part repaired. All raw edges of new fabric on the outside are covered with thin strips of cushion gum, the opening in the tread is filled up carefully, all ragged edges are trimmed even with the casing, the inside and outside of the tire are dusted with soapstone, and the repair is ready for vulcanizing.

15. A half-sectional repair ready to be built up is shown in Fig. 12. In this case, the side wall *a* is removed for at least 4 inches from the extreme edges of the injury, and the chafing

strip is removed about $\frac{3}{4}$ inch inside of the edges of the side wall. The top ply *b* is stepped out $1\frac{1}{2}$ inches from the edges of the side wall section in the direction of the hole, and extends at the top to about 1 inch from the farther tread line, and at the bottom to the edge of the bead. The second ply *c* is removed about 1 inch narrower all around than the first.

The old fabric is replaced by new as described in connection with the full section repair, the top ply being cut long enough to extend from bead to bead on the inside of the tire. At the point where the fabric passes over the bead, it is skived so as to make a butt joint with the old fabric. When this ply is stitched in place, a cover of thin cushion stock is placed on the section being repaired, the chafing strip is replaced lapping the old strip about $\frac{1}{4}$ inch at each end, and is carried over into the inside of the tire about an inch, and a new section of side wall is applied. The tread is laid back, the **V**-shaped space and injured section filled up with raw gum in the manner described for the full-section repair, the inside and outside dusted with soapstone, and the job is ready for vulcanizing.

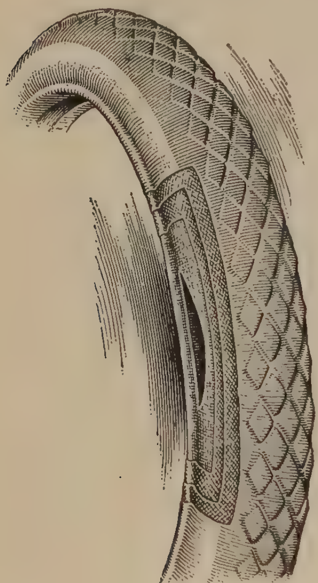


Fig. 13

16. Rim Cuts.—In a quarter-section repair, the side wall is removed for a distance 4 inches from the extreme edges of the injury, and the edges are skived carefully. As illustrated in Fig. 13, the chafing strip is removed to within $\frac{3}{4}$ inch of the ends of the removed side-wall section on each side, and the top, or outside, ply is removed to about $2\frac{1}{2}$ inches from the edges of the injury, and extending up to within $\frac{3}{4}$ inch of the tread line. The next ply is stepped out $\frac{1}{2}$ inch lower at the top than

the top ply and 1 inch shorter at each end. Both of these plies are removed to the toe or inner edge of the bead. A stepped down quarter section ready to be built up is shown in Fig. 13.

After the injury has been prepared for the addition of the new fabric, as already described, all edges of the old fabric are covered with strips of raw gum about $\frac{1}{4}$ inch wide. The new section is built up as in the other cases, the top ply extending over the bead and about half way up the tire on the inside. The chafing strip is replaced overlapping the ends of the old one, and extending an inch inside of the tire. Before the fabric of the top ply is stitched in place, the hole in the casing is filled with tread stock and a thin strip of raw gum is placed over it. The casing is then dusted with soapstone, and is ready to be cured.

17. Retreading.—The operation of retreading is comparatively expensive, and should be done only after making sure that the remainder of the tire is in good enough condition to warrant the expense. The cost of retreading approaches so nearly the price of a new tire, that in the great majority of cases, it will prove more economical in the end to purchase a new tire. The fabric of the casing must be firm and not separated between the layers, and the side walls above the bead must be in good condition, if any extended service is to be obtained from a retreaded tire. In making this repair, the old tread, breaker strip, and cushion stock are removed with a sharp knife down to the bare fabric. A rotary rasp may be used if the tread is so badly cut up as to be difficult to skin with a knife, but in any case, care must be taken not to gouge into the fabric or the body of the case. The casing is then buffed carefully with a rotary wire brush until all small particles of rubber are removed from the fabric. If there is a cut in one or two of the plies but the remainder of the tire is in good condition, the injuries may be repaired as already explained, and the new tread added afterwards.

18. When the casing has been cleaned properly from the tread line on one side to the tread line on the other side, the buffed surface is given two coats of vulcanizing cement, applied as previously described. When this cement has dried to such

an extent that all solvent has evaporated, the tread is built up by applying two plies of $\frac{1}{32}$-inch-gauge cushion gum, the first or under ply extending to within $\frac{1}{2}$ inch of the edges of the cemented surface, and the second cut $\frac{1}{2}$ inch wider than the breaker strip that is to be used. Care should be observed to center the second strip around the tire. The breaker strip is then applied. In preparing this strip, it should be cut lengthwise with the threads of the fabric, instead of on the bias, as in the case of cord tires. When the breaker strip is in place, a layer of $\frac{1}{16}$-inch-gauge tread gum wide enough to extend from tread to tread is applied over it, and the repair is ready for the application of the retread band.

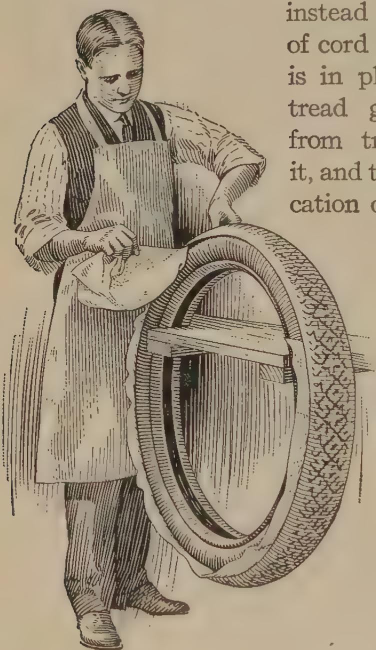


Fig. 14

19. The retread bands are made for the trade built up, semi-cured, and ready for application. Before being applied to the prepared casing, the band should be buffed thoroughly and given two coats of vulcanizing cement. When the retread band is ready to be applied, a piece of clean muslin is placed over the cover-stock, and the band is stretched into place. When the band is properly centered on the tire, the muslin is removed, and the tread is rolled and stitched firmly in place. The muslin prevents the retread band from sticking to the casing while being centered; the method of withdrawing it is shown in Fig. 14. When the band is stitched down properly, the edges are trimmed to from $\frac{1}{2}$ inch above the edge of the undercover in 3-, $3\frac{1}{2}$-, and 4-inch tires, to $\frac{3}{4}$ inch in $4\frac{1}{2}$- and 5-inch tires. The retread is now ready for curing.

20. Table I, giving the over-all diameter, over-all width, and breaker-strip width for tires of various sizes was prepared from data supplied by the Goodyear Tire and Rubber Co., Akron, O. The length of the breaker strip and of the tread band can be calculated by multiplying the over-all diameter by 3.1416.

TABLE I

TIRE DIMENSIONS, IN INCHES

Size of Tire	Type of Tire											
	Straight-Side Fabric			Clincher Fabric			Straight-Side Cord			Clincher Cord		
Inches	Over-all Diameter	Over-all Width	Width of Breaker Strip	Over-all Diameter	Over-all Width	Width of Breaker Strip	Over-all Diameter	Over-all Width	Width of Breaker Strip	Over-all Diameter	Over-all Width	Width of Breaker Strip
30 × 3	....	....	....	30.5	3.0	2.5	....	....	....	....	....	....
30 × 3½	....	....	...	30.9	3.4	2.5	....	....	....	31.6	3.8	3
31 × 4	....	....	....	32.0	4.0	3	....	....	....	....	....	....
32 × 3½	33.3	3.7	2 5	....	....	....	33.4	3.8	3	....	....	....
32 × 4	32.6	4.0	3	....	....	....	33.5	4.4	3.5	....	....	....
33 × 4	33.7	4.0	3	....	....	....	34.6	4.4	3.5	....	....	....
34 × 4	34.6	4.0	3	....	....	....	35.5	4.4	3.5	....	....	....
32 × 4½	32.7	4.5	3.5	....	....	....	33.9	5.0	4	....	....	....
33 × 4½	33.7	4.5	3.5	....	....	....	34.5	5.0	4	....	....	....
34 × 4½	34.8	4.5	3.5	....	....	....	35.9	5.0	4	....	....	....
35 × 4½	35.8	4.5	3.5	....	....	....	36.6	5.0	4	....	....	....
36 × 4½	36.8	4.5	3.5	....	....	....	37.7	5.0	4	....	....	....
33 × 5	34.0	5.2	4	....	....	....	35.8	5.8	4.5	....	....	....
35 × 5	36.0	5.2	4	....	....	....	37.7	5.8	4.5	....	....	....
37 × 5	38.0	5.2	4	....	....	....	39.0	5.6	4.5	....	....	....

21. It is often desired to replace a section of the tread of a non-skid tire without disfiguring the tire with a smooth patch. This can be done by use of a negative pad having depressions corresponding to the raised figures on the tread. Such a pad is made up of one ply of bead fabric and two plies of $\frac{1}{16}$-inch tread gum, cut wide enough to cover the tread and

long enough to extend one inch beyond the section of tread with which it is to be used. The pad is dusted freely with soapstone, and imprinted by fitting it over a good section of the tread, and is then cured. In using this mold, the raw section of the tire is powdered with soapstone, and the edges of the mold or pad are treated with self-curing cement. When the mold is applied to the section, the cement will hold it in place until the cure is effected on the section; the mold can then be removed. When this pad is used, 20 minutes longer than usual are required to cure the section. The pad can be used several times.

22. **Double-Treading.**—By means of the double-treading process two old tires may be made into one good tire. A tire with a good tread and another one with a good bead are selected; the bead is removed from the first tire, the edges are beveled at each side, and it is then placed over the tire that has the good bead and is fastened in place. In some cases the union of the two tires is obtained by stitching, but this is not considered the most satisfactory method, because of the danger of injury to the inner tube by the stitches, and because there is a firm contact between the two only at the point of stitching.

A very good method of making a double-tread tire is to cut off the bead evenly from the tire having a good tread, bevel both edges, and clean the inside thoroughly. Then clean the outside of the tire having a good bead, which is the tire to be used on the inside, and apply three coats of vulcanizing cement to both cleaned surfaces. When the cement has dried properly, a sheet of thin raw gum is placed on the surface of the tire to go underneath, and the outer casing is then placed over this and vulcanized.

23. **Recovering.**—When the fabric of a tire warrants the expense, the casing may have a complete outer covering put on it. This is known as *recovering* or *half-soling*. It is a waste of time and money, however, to cover over an old casing in which the fabric has rotted or broken loose, as the tire will blow out long before the new cover has worn out.

To recover a tire, the entire old side-wall rubber, tread, and chafing strips are removed, and the fabric body cleaned of all rubber and foreign matter. The surface of the cleaned casing is then given three coats of cement, and new material is added as in the case of retreading. New coverings can be purchased ready for application, and when these are applied to good casings, the life of the tire is prolonged for thousands of miles.

24. Sand Blisters.—A sand blister is prepared for vulcanizing by cutting half way around the blister with a sharp knife, cutting through the rubber to the canvas on the side of the blister away from the tread of the tire. The flap thus formed should be turned back and pinned down, as shown in Fig. 15, and all dirt removed from under it. Then the cut should be cleaned and cemented with vulcanizing cement as for an ordinary casing cut. Next, a strip of inner-tube stock as wide as the tire rubber is thick should be stuck on the edge of the flap and a thin sheet of the same prepared rubber the exact size of the cavity laid on the canvas and pressed down. The flap can now be laid back in place and the repair vulcanized, the time allowed depending on the particular vulcanizer used. The sand blister is caused by sand entering through a cut or small hole in the tread, and working its way underneath the tread. This hole may be several inches away from the blister. After repairing the sand blister, care must be taken to stop up the hole through which the dirt entered, as, otherwise, another blister may form at some other point.

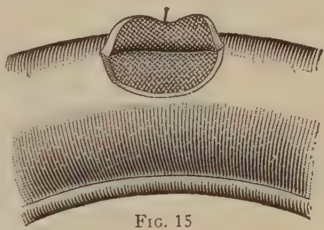


FIG. 15

REPAIRING CORD CASINGS

25. Multiple-Cord Casings.—The cord patch, described in *Automobile Tires*, Part 2, makes a very satisfactory repair when the injury is not more than $3\frac{1}{2}$ inches long, and when it is located in the section covered by the tread. The

casing should be prepared for vulcanizing, by buffing it on the inside over a space somewhat larger than the area of the patch to be applied, freeing the injured section of all loose fabric and rubber, tapering the hole so that it is larger inside than outside, and then buffing and cleaning the edges of the hole thoroughly. Three coats of vulcanizing cement are applied to the buffed inner surface of the casing and the edges of the hole, and each coat is allowed to dry separately; after which the cloth covering is removed from the patch, the uncured face moistened with gasoline, and the patch is applied firmly to the cemented surface. The patch must have its oval portion directly over the hole, and when set properly all over, the edges are trimmed off carefully where they project beyond the bead. The tire is then turned over, the injury filled up with small strips

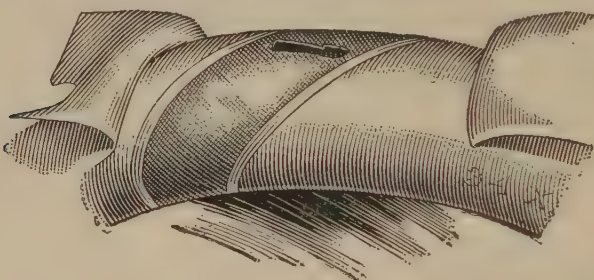


FIG. 16

of tread stock kneaded firmly into place, the inner and outer surfaces dusted with soapstone, and the repair is ready for curing.

26. Holes through the casing too large to be repaired safely by the cord patch, or holes between the tread and the bead, must be repaired by the sectional method, in much the same way as in the case of fabric tires; but cord fabric should be used instead of cotton fabric, and a $1\frac{1}{2}$-inch lap should be left between the steps instead of a 1-inch lap, as in fabric tires.

27. In cord tires in which the inside plies run in opposite direction to the outside, the *cross repair* is the most satisfactory. To make this repair, the tread and breaker strip are cut through at the point of injury, and laid back for about 5

inches on each side. Two or more plies of cords, according to the size of the tire, are removed, the first layer leaving a margin of about 1 inch on both sides of the extreme points of the injury, and extending from bead to bead, and the second ply $\frac{1}{2}$ inch narrower at each side than the first, and also extending from bead to bead. The chafing strip and side walls are then removed about $\frac{3}{4}$ inch farther back than the edges of the larger step. The outside of the casing torn down is shown in Fig. 16.

Next, the tire is turned over, the inside spread out, and the same number of plies removed from the inside as from the outside, each ply being stepped in the same way as those on the outside. The inner chafing strip is then laid back to the edge of the bead for a distance of $\frac{3}{4}$ inch on each side of the

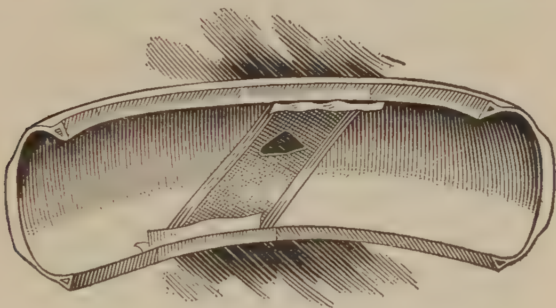


FIG. 17

widest step. The inside of the casing ready for building up is shown in Fig. 17.

The exposed surface, both inside and outside, and the edges of the hole are buffed thoroughly, the buffing on the inside being carried on over a space large enough for a cross patch, and 3 coats of vulcanizing cement are applied. When the cement has dried, a ply of $\frac{1}{32}$-inch cushion gum is applied to the inside where the old cords were removed, and new plies of cord fabric wide enough to fit the steps without lapping, are worked into place. When these plies are stitched down firmly, an equal number of plies of cord fabric are placed over them but at an angle of 45°, also extending from bead to bead. This section is about 2 inches wider than the hole in the casing,

and is made with the plies underneath stepped $\frac{1}{2}$ inch, so as to make a smooth union of its edge and the inside of the casing. The fabric is appl ed with the gum coated side down. The built-up cross repair is shown in Fig. 18.

The injury is filled up from the outside with raw tread gum, and the outside plies are replaced in the same way as the inside ones. The chafing strip is replaced, the new strip overlapping the ends of the old about $\frac{1}{4}$ inch; and new side walls are applied, after which the tread and breaker strip are laid back and stitched thoroughly into place. The **V**-shaped opening made by the beveled ends of the tread is filled up with tread stock, the casing is dusted with soapstone inside and outside, and is ready for the vulcanizer.

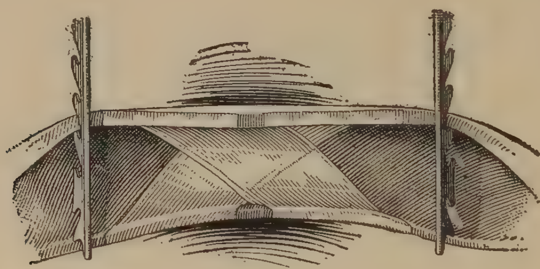


FIG. 18

Multiple-cord tires are retreaded in the same manner as fabric tires. Before it is decided to retread a tire, it should be examined carefully, and if there is evidence of ply separation, the probabilities are that the tire is not worth the expense.

28. Cable-Cord Tires—Clincher Type.—When only the outer cords, or cords next to the tread, are broken, the first step is to note the extent of the injury to the tread. If the tread is badly damaged, it must be cut away, and a new section inserted, as will be described later; but if the damage is light, as in the case of a small cut, it will not be necessary to remove any part of the tread.

If it is necessary to remove the tread in the region of the injury, this should be done first, and then the tire turned inside

out. With a pencil or piece of chalk, a mark is made on the inner surface of the casing from bead to bead, through the center of the injury, as nearly as can be judged by the eye, and in the direction of the inner ply of cords. Another line is then drawn through the same center, but in the direction of the outer ply of cords, which is diagonal to that of the inner cords. The manner of drawing these lines is shown in Fig. 19, where *ab* indicates the direction of the inner cords and *cd* the direction of the outer cords. Next, the inside bead cover *e*, Fig. 19, on each side of the tire is loosened with an awl, cut, and laid back to the edge of the bead for about 2 inches beyond the points *ad*

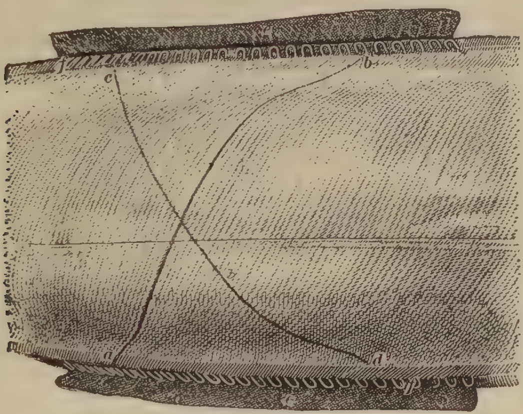


Fig. 19

and *cb*, where the ends of the lines terminate in the bead. The staples *f* by which the cords are fastened to the bead are then exposed, and these staples are removed between the points *c* and *b* on one side and *a* and *d* on the other side, but those in the 2-inch margin at each end of the lines are left in.

29. The staples having been removed, the next step is to lay back the inner cords. The awl is run deeply between the cords along the line *ab*, or the cords nearest to the inside of the casing, and the loops of cord between points *a* and *d* are loosened from the tire and laid back as shown in Fig. 20. The looped ends of the cords at the opposite side are now loosened

and laid back between points *c* and *b*. Both flaps are fastened back, and the injury in the outer, or cords nearest to the tread, is now exposed, as shown in Fig. 20.

In removing the damaged cords, it is advisable to remove a few extra cords on each side of the injury to insure plenty of room for working, and to give greater strength to the repaired section. When the cords to be removed are decided upon, the awl is used to loosen the ends of the injury, and with a pair of pliers, the cords are removed, one at a time, until the desired

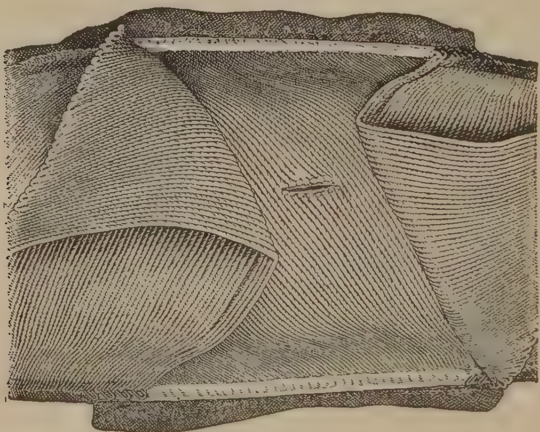


FIG. 20

number has been removed at each side. The tire will then have the appearance shown in Fig. 21. All exposed surfaces *a*, *b*, *c*, and *d*, as well as the channel *e* made by the removal of the damaged cords, must be cleaned and buffed carefully, after which the casing is ready for rebuilding.

30. In replacing the damaged section, a cord section of the same number of cords as the part removed, is selected from a casing of the same cross-sectional diameter as the tire being repaired. When this is done, the tire is turned right side out and the cords are fitted (not fastened) to the space they are to occupy to make sure that they will exactly replace the removed ones. Both the casing being repaired and the

replacement section are then dried thoroughly, the casing is turned wrong side out again, and both members are treated with vulcanizing cement. Two medium coats are applied to the buffed surfaces of the casing and to one side of the new cord section, the first coat being allowed to dry for an hour or two, and the second from 6 to 8 hours. When the cement has dried properly, a thin strip of $\frac{1}{64}$-inch cushion gum is placed on the new section on the side which is to be in contact with the side walls and tread when applied. The cemented surfaces of the exposed cords which were turned

Fig. 21

back, are also covered with the same cushion gum, and the tire is once more turned right side out. The new section is laid in, one end being applied first and then the section is stitched down thoroughly from this end to the other; the flaps, or lifted inner ply of cords, are laid back in place, and the staples are inserted. The inner ply is rolled and stitched firmly in place, after which, a strip of $\frac{1}{64}$-inch cushion gum is laid over the cords, so as to extend not more than $\frac{1}{4}$ inch above the bead strip, and the bead covers are replaced. A strip of the cushion gum is then laid over the line where the inner cords were divided, the cut is filled with strips of tread stock,

and the tread rubber, if it has been removed, is replaced. The tire is then ready for vulcanizing.

31. In case an injury extends through both the inner and the outer plies of cords, the same method of repair is followed as just described, excepting that the injured cords from the inner ply, which is folded back, must also be replaced. The outer ply, that next to the tread, must be repaired first, after which, the inside ply is folded back into place, the defective

Fig. 22

cords having been removed, new cords are inserted in the inner ply, and the casing is ready for the vulcanizer.

32. When cords are broken along the bead, the side wall is first cut away for about $1\frac{1}{4}$ inches above the injury, and about 2 inches beyond the ends of the injury. The damaged section of the bead is then removed by cutting through it at each end of the injury, and splitting the bead about half way between the inner and outer edges, as shown in Fig. 22. From another bead of the same size as the one being repaired, a section is cut of the same length and shape as the one removed. Both the exposed section of the tire and the piece of bead that is to be inserted are buffed and cleaned thoroughly, and covered with

cement. Two medium coats of vulcanizing cement are applied and allowed to dry properly, after which the exposed cords are covered with a ply of $\frac{1}{32}$-inch cushion gum. A piece of gum is lapped over the exposed ends of the bead, and the new bead section is placed in position. When the upper part of the new bead is stitched to the side wall, and the clincher channel is formed with the stitcher, a piece of bead cover is applied so as to extend about $\frac{1}{2}$ inch above the junction of the bead and the casing, as shown at *a*, Fig. 23. Another section *b* of bead cover is placed over the first, but extending not quite so far up the side wall as the lower one, and a $\frac{1}{2}$-inch strip of cushion gum *c* is placed over the ends of both bead covers and overlapping

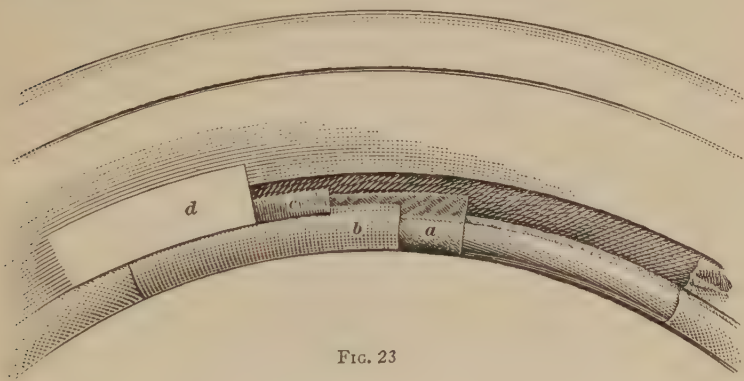


Fig. 23

the side wall, so as to bind them firmly together. A piece *d* of side-wall gum is now applied to replace the removed section of side wall, and the repair is ready to be cured.

The new sections of material *a*, *b*, *c*, and *d*, of Fig. 23, extend, of course, the full length of the section under repair, being cut off in the illustration to show their relative positions, and method of application.

33. When cords of one layer, or ply, become separated from the other layer, the first step is to examine the tire and locate the loose cords. Then a section of the inside bead cover is removed at one end of the loose cords, the staples holding these cords are pulled out, and the cords are turned back beyond the

points where they are separated from the other ply. The cords and bead covers are buffed clean, and two medium coats of vulcanizing cement are given them. When the cement is dry, a sheet of thin cushion gum is applied to the exposed outer ply, and the inner cords are pressed back into place. The staples at the ends of the cords are replaced, the cords are stitched down well and covered with a layer of $\frac{1}{64}$-inch cushion gum, and the loosened section of inside bead cover is pulled down over the staples and rolled into place.

34. Cable-Cord Casings—Straight-Side Type.—In repairing a straight-side cable-cord tire, the first step is to determine the angle at which the outer cords are laid in the casing. This is done by taking a section from an old cord tire of the same size and laying it over the outside of the tire with the ends at the beads, as shown diagrammatically in Fig. 24. The ends *a*, *b*, of the line passing through the center of the injury should then be located and a mark made in the bead at each point. If the injury is large enough to make necessary the removal of six or more cords, a piece of the outside bead cover should be removed at each side for about $1\frac{1}{2}$ inches up the side wall, and about 1 inch each side of the cord section that is to be removed, as shown at *a*, Fig. 25. The casing is turned inside out, the inside cord passing through the center of the injury is located, and a chalk line drawn over this cord, as was described in the case of clincher tires. A line is then drawn through the two points previously located as illustrated in Fig. 24, and these two lines should intersect near the center of the injury. The four points on the beads having been determined exactly as shown in Fig. 19, the casing is cut along the mold seam which runs through the base of the bead, or that part of the bead

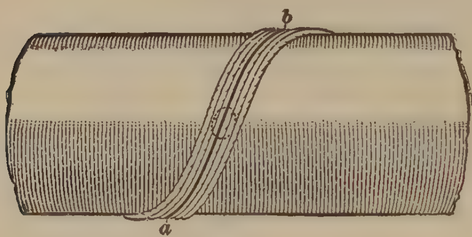


Fig. 24

which lies on the rim when the tire is in place. This cut should extend between the two points determined on each side of the bead by the terminals of the crossed lines, as *ad* and *cb*, Fig. 19, and the greatest care must be taken to keep from cutting into the cords while making the cut. The bead cover is cut through about an inch beyond the points at the ends of the crossed lines, and this cover is loosened from the bead to the inner edge of the bead, as shown at *b*, Fig. 25.

35. Beginning at the line passing through the center of the injury in the direction of the inner cords, as *ab*, Fig. 19, the inside cords are loosened with an awl at both ends of the line, and the loosening process is carried along the bead on both sides until the inner ply can be laid back as shown at *a* and *b*, Fig. 26, so as to expose the outer cords *c* and the injury *d*. Under no circumstances should the inside bead strip be loosened from the inner cords, as it holds the cords securely in their original position when the ply is laid back.

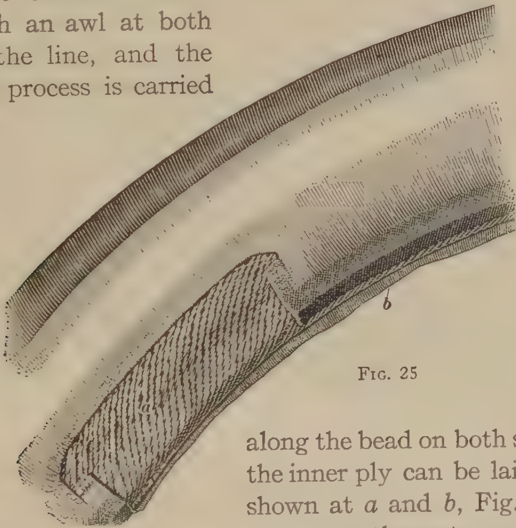


FIG. 25

The cords cut by the injury *d*, Fig. 26, are removed one at a time by the awl, the removed side wall shown in Fig. 25 making it possible to pass the injured cords down under the bead to remove them entirely. When all cords affected by the injury are removed, not in any case less than 6 cords, the entire exposed surface is buffed, dried, and cemented in exactly the same

manner as in the case of clincher tires, except that the buffing process on straight bead tires is not quite as thorough as on the clincher type, in order not to remove any of the rubber from between the cords. The new cord section is prepared and inserted in the same way as described for clincher tires, and the outer ply is folded back into position. It must be remembered to cover all cemented surfaces with a thin layer of cushion gum. When the injury has been repaired, the side wall must be built up with side-wall gum, and the tread, if removed, must be replaced.

36. Retreading Cable-Cord Tires.—Tread patches or tread sectional repairs can be employed when the tread rubber

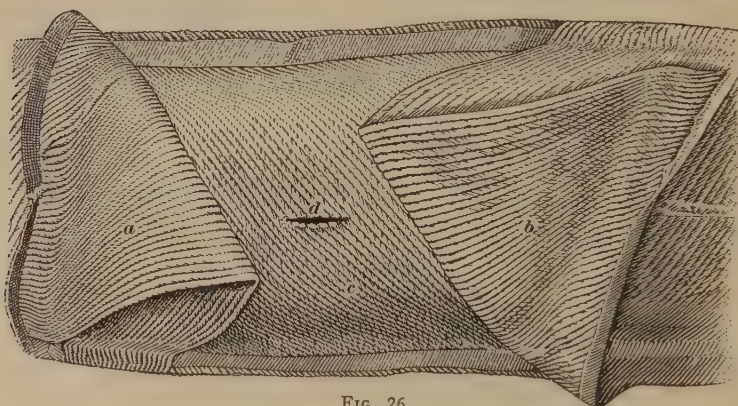


Fig. 26

is cut in places without injury to the cords. Such repairs must be made immediately to prevent damaging the cords and thereby causing the necessity for greater repair.

To prepare the tire for a tread patch, the tread is examined and pried into to determine the extent of the injury. If the tread is not loose from the casing, or if no cords are injured, a mark is made on the tread about one inch beyond the limits of the injury in each direction. In case of looseness, the marks must be made beyond each end of the loose portion.

The rubber is removed by cutting along the marks made on the tread through the breaker strip to the cords, care being taken not to cut the cords. With a pair of pliers *a*, Fig. 27,

one end of the tread section *b* which is to be removed, is grasped and pulled back, the section being loosened from the cords by scratching between the tread and the cords with the awl *c*. When a large patch, say 4 inches or more, as *b*, Fig. 27, is removed, a power driven buffer brush should be used to clean and roughen the exposed surface. For small patches, as at *d*, the cleaning and buffing must be done by hand. A good way to do this is by using a small round piece of hard wood, sharpened to a blunt point. With this instrument, the rubber remaining on the cords can be scraped off, the point serving to clean the

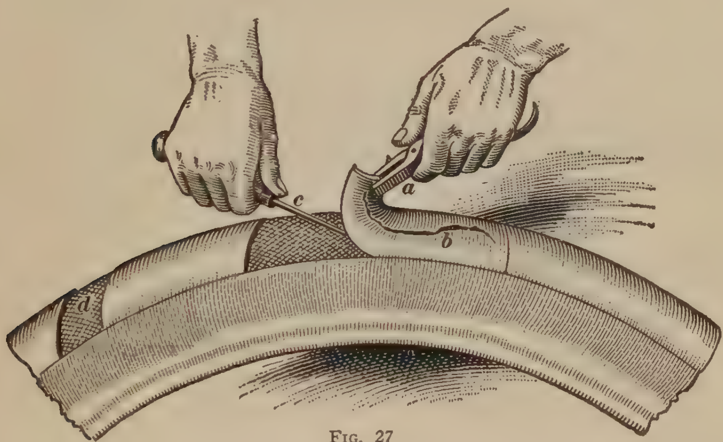


Fig. 27

edges and corners of the opening. A rasp is then used to roughen the cords, and rubber ends of the tread so that the cement will stick. After being rasped, the cords are brushed with a brush with stiff bristles, and the casing is dried out thoroughly.

Two medium coats of cement are applied to the cleaned surface and allowed to dry, as in the other repairs described, and the cords are covered with a layer of $\frac{1}{32}$-inch cushion gum. The section of breaker strip is laid in, the exposed ends of the tread are covered with small strips of cushion gum, and a ply of tread stock is stitched into place. An impression pad, as previously described, should be used to give the tread section the same non-skid design as the remainder of the tread.

37. In case the tread is worn down all around and an entire new tread is necessary, the first step is to remove the old tread. The tread cannot be pulled off as in the case of fabric tires, but must be cut off in strips with a sharp knife. Before starting the stripping process, it is a good plan to mark the casing all around on both sides along the tread line, to insure a neat and even job. After the casing is marked, the tread and breaker strip are cut away leaving just a thin surface of cushion gum over the cords. To attempt to remove all the rubber with the knife, is to endanger the cords. The exposed surface of the casing is now buffed thoroughly with a medium stiff wire brush. Under no condition should a rasp or stiff brush be used. The side walls are beveled so as to make a smooth overlap of the new tread, and the outer ply of cords is roughed carefully, great care being taken not to weaken the cords by too much roughening. The surface is then brushed to remove all dirt and loose fibers of fabric and is ready for cementing. The finished surface is shown in Fig. 28.

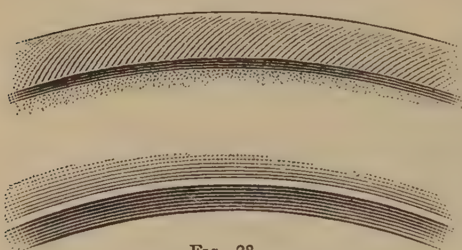


FIG. 28

The method of replacing the tread is the same as explained fully in Arts. **17** to **21** in connection with fabric casings, except that the breaker strip is cut on the bias for cord tires.

VULCANIZING EQUIPMENT

VULCANIZERS

38. In equipping a shop for the vulcanizing of tires, it is usually a good plan to start on a small scale, and then increase the equipment as the business requires. The vulcanizers illustrated in this Section are shown as examples of the various

types on the market and not because of any superiority they may have over other types used for similar purposes.

39. Wrapped-Tread Vulcanizers.—The steam vulcanizer shown in Fig. 29, and manufactured by the C. A.

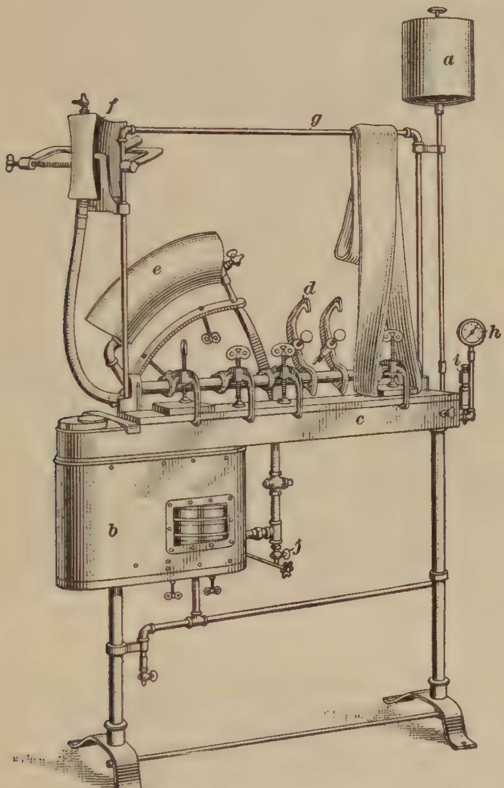


FIG. 29

Shaler Co., Waupun, Wis., is used with the wrapped-tread method of repair. It is particularly adapted to the small repair shop, as it requires no separate boiler, gas or gasoline being used to provide the necessary heat, and it will vulcanize casings and tubes at the same time. The vulcanizer is provided with automatic temperature control, and requires

no attention on the part of the operator other than removing the tire at the proper time. In the illustration, the gasoline tank is shown at *a*, the boiler at *b*, the tube plate at *c*, the tube clamp at *d*, the inside casing mandrel at *e*, the outside casing form at *f*, the tube rack at *g*, the steam gauge at *h*, the safety valve at *i*, and the blowoff valve at *j*. The method of using the inside casing mandrel *e* and the outside form *f* is described in Art. **10**, and illustrated in Fig. 10 in connection with casing repairs. The casing forms are supplied in a variety of sizes, so as to take care of different size tires. The method of clamping and suspending the inner tube is shown in Fig. 29.

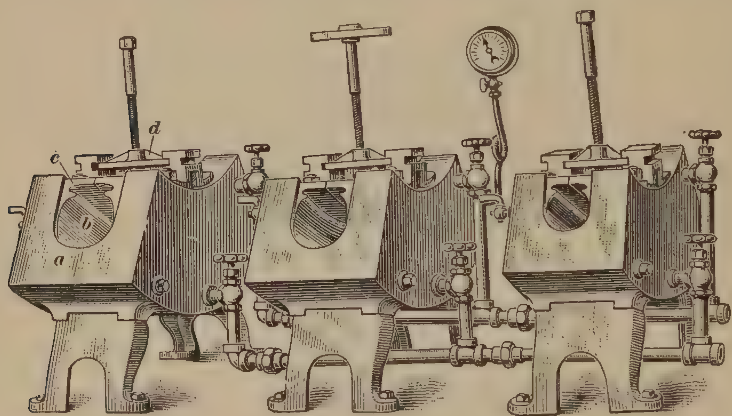


FIG. 30

Complete instructions accompany these vulcanizers when sent out from the factory, and these instructions should be followed carefully when first using the machines, if good results are to be obtained.

40. Outside-Repair Vulcanizers.—A vulcanizer for curing outside-repaired casings, and for use when the steam is supplied by a separate boiler, is shown in Fig. 30. It is manufactured by the Akron Rubber Mold and Machine Co., Akron, Ohio. As shown in the illustration, the vulcanizer consists of 3 single cavity molds, which allow of vulcanizing 3 different-size tires at the same time. Other molds can be connected into

the system to take care of other-size tires, as the occasion requires. As is seen in the figure, the mold proper consists of a hollow casting *a* with an opening *b* shaped to the contour of the tire at the bottom, and with sides perfectly smooth. The bead mold *a* must fit the opening *b* correctly, as this fit determines largely the successful curing of the casing. Examples of bead molds are shown in Fig. 31, (*a*) being for straight-side tires, and (*b*) for clincher tires. The two halves of the bead mold are held together by bolts, as shown, or are clamped together by adjustable clamps.

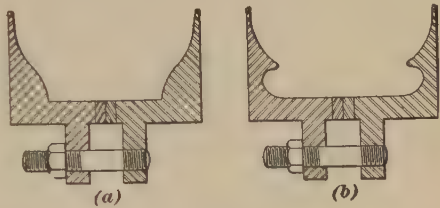


FIG. 31

To use the vulcanizer shown in Fig. 30, the repaired section of the tire and the mold are sprinkled freely with soapstone, and a sectional air bag is placed in the tire. A thin strip of damp muslin as wide as the tread and a little longer than the part being repaired, is applied to the outside of the tire, the bead molds are fitted into place, and drawn together either by clamps or by bolts. The tire is then placed in the mold, the clamps *d* are screwed down tight on the bead mold, and the air bag is inflated to 70 pounds pressure. The air bag used for this purpose is shown in Fig. 32.


FIG. 32

41. When the repaired section is very small, a bag of sand, Fig. 33 (*a*), of the same size as the air bag, and a rectangu-

lar steel bar (*b*), 1 inch × 1 inch × $\frac{1}{5}$ circle, with the same curvature as the mold, may be used instead of the air bag. After soapstone is sprinkled on the casing and mold, and the

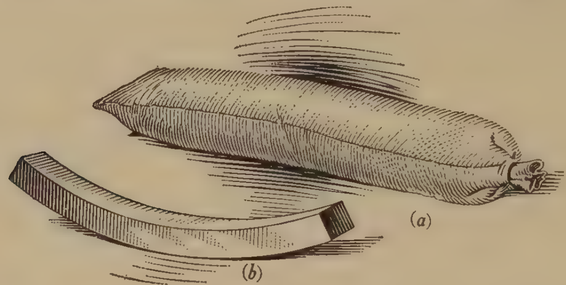


FIG. 33

strip of damp cloth is applied, the sand bag is inserted and the tire is placed in the mold. The curved bar is then laid on the bag, and the clamps are screwed down on the bar. This spreads

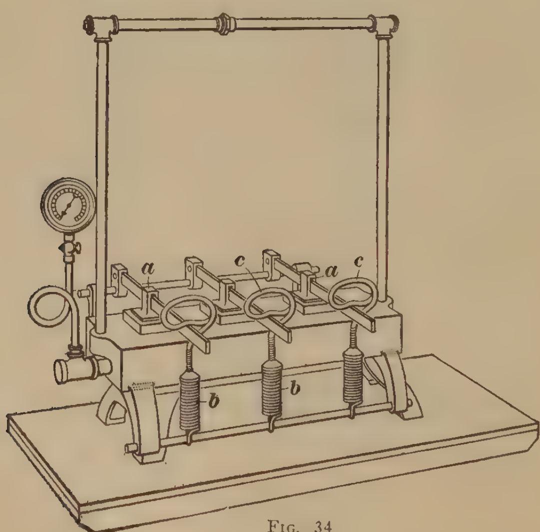


FIG. 34

the bag, and gives the necessary pressure on the repair. After the repair is cured, the surface should be cleaned with fine emery cloth or sand paper to remove all loose or protruding edges.

The sand bag should be filled with fine dry sand, but should not be packed tight. A small amount of fine flake graphite mixed with the sand will prevent bunching or caking.

42. The non-skid design on the tread of any tire can be duplicated by using the tread pattern described in Art. 20. In case it is desired merely to prevent the tread pattern from being flattened by the pressure on the tire, a very thick paste is made of powdered soapstone and water, and the depressions in the tread are filled up before placing it in the vulcanizer. When the cure is finished, the dried soapstone is brushed off and saved for future use.

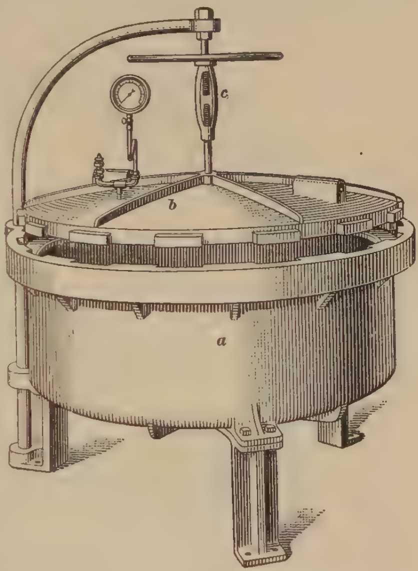


FIG. 35

43. Tube Vulcanizers.—An inner tube vulcanizer manufactured by the Williams Foundry and Machine Co., Akron, Ohio, is shown in Fig. 34. The vulcanizer illustrated is intended for three tubes, but this type is also made in six-tube and eight-tube sizes. No weights are required as the clamps *a* are held down by the springs *b*, and the tube can be inserted or removed instantly by simply unlatching the handle *c* from the clamp arm *a*.

44. Retreading Drum.—A boltless vulcanizer, also manufactured by the Williams Foundry and Machine Company, used for retreading purposes, is shown in Fig. 35. It consists of a drum *a*, having a cover *b*, operated by a crane cover-handling device *c*. The drum is provided with a bottom grate that permits steam to circulate all around the tire, and the crane

device *c* makes possible the handling of the cover *b* with very little trouble. To cure a retreaded tire in the vulcanizer shown, an endless air bag, Fig. 36, is inserted in the casing, split rims are placed on the tire, and its outer surface is covered with a damp muslin jacket extending just below the tread line. The tire is then wrapped spirally with a strip of light duck about 2½ or 3 inches wide twice around, the second winding being in opposite direction to the first. The turns of duck should over-

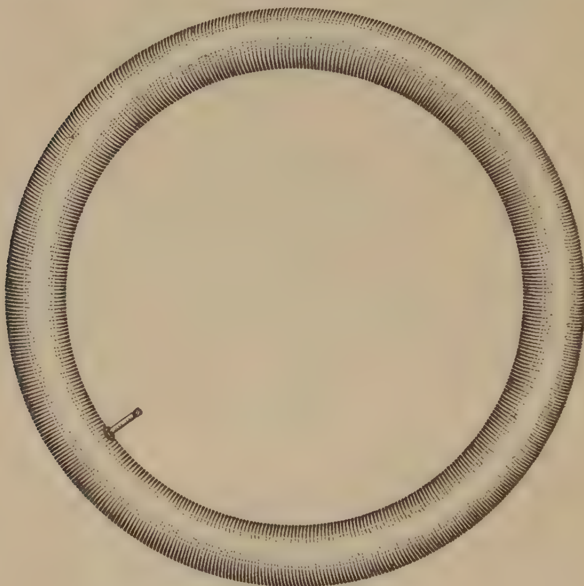


Fig. 36

lap, and must be drawn tight. The air bag is inflated to 40 or 50 pounds pressure, and the tire is placed in the curing drum. After the cover is lowered into position, it is given a slight turn to lock it in place, and the steam is turned on.

It is very important that an air bag of correct size be used, as one that is too large may be pinched, while one not large enough will not properly fill the interior of the casing. Instead of using an air bag, an endless retread coil as shown in Fig. 37 may be employed. This coil can be opened or closed to fit

tires of various cross sections, and can be lengthened to fit the tire in which it is to be used. To insure a good, smooth surface, it is advisable to use a fabric pad around the coil.

45. Sectional Tread Molds.—Sectional tread repairs are made in retread molds, these molds being practically the same as sectional vulcanizers, except that they are longer and not so deep. A sand bag is used in making the sectional retread, and the pressure is obtained by means of the clamps and pressure

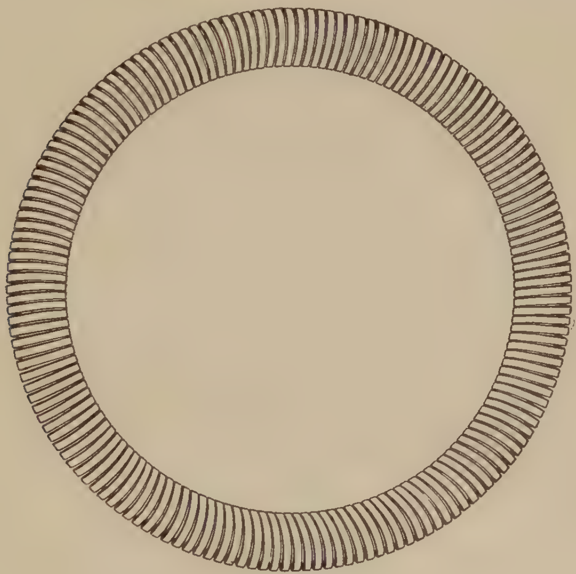


FIG. 37

bar. The sand bag must be just as long as the mold, and of sufficient diameter to insure good pressure on the side walls. The pressure bar must be of the same curvature as the mold; otherwise, flat spots will occur on the tread surface between the points where the clamps are applied. In applying the pressure, the clamps are tightened down gradually, starting at the middle and working towards the ends. The tire is held in an upright position, and the clamps are not drawn up tight until after the curing has been going on for about 10 minutes. If

blisters appear at the ends of the mold, they must be opened immediately with an awl so that the air can escape.

In some cases a tire is entirely retreaded by the process just described. The mold is long enough to extend a little more than one-third of the way around the tire, and the tire is vulcanized in three positions. A lap of 5 or 6 inches on the previously cured section must be allowed in each case, and it is absolutely necessary that exactly the same length of cure be given to each section.

REPAIR STOCK

46. In stocking up a tire-repair station, it is better in the long run to purchase nothing but the best materials; and the only way to be sure of this is to deal with recognized, reputable, manufacturers.

As soon as the vulcanizing materials are received from the factory, the rolls should be removed from the boxes, and suspended on racks made for that purpose. If the rolls are allowed to lie on the floor, the weight will cause the material to stick to the liner, and if stood on end, the material will wrinkle, and stick to the liner, making it hard to work with later. The materials should not be stored in a warm room, nor be exposed to dampness, sunlight, or a direct draft. In summer, when it is impossible to keep the temperature even, the rolls should be turned over frequently to prevent sagging. If the material is received during cold weather, it may appear hard and lifeless; in which case, it should be placed in a warm room long enough to thaw out before being used.

It is a good plan to purchase materials in small lots in order to keep the stock fresh. All uncured gum trimmings can be returned to the factory, and allowance will be made for this returned material on a future order. Different gum trimmings should be kept separated, and must be absolutely free from cured gum, fabric lint, dirt, etc., if full allowance is to be obtained. When the uncured gum is returned to the factory, it should be well wrapped up to protect it in transit, and each box should be marked plainly with the number of the gum.

In using repair materials, all dirt or bloom collected on the surface must be washed off with gasoline before the material is used, as otherwise an imperfect union may result.

47. Cement.—The cement used for vulcanizing should be of the best quality, and in most cases, the best practice is to buy it ready prepared from a recognized supply house. Homemade cement, as a rule, is not very economical; but if it is desired to make it, a good cushion gum, and a high-test gasoline should be used. The gum should be cut into small strips and dissolved in a can containing the gasoline, the mixture being stirred frequently until it reaches the consistency of cream. Tread stock should never be used for making cement, because, due to its composition, it is not entirely soluble.

Each time before using, the cement should be stirred thoroughly, and when applied, must be allowed to dry naturally. In case it is necessary to thin the cement, a very high-grade gasoline, one that will leave no oil residue when allowed to evaporate from a sheet of white paper, or benzine should be used as a solvent. Cement should be stored in a cool, dry room, and kept covered at all times when not in use.

MISCELLANEOUS EQUIPMENT

48. A vulcanizing station must be equipped with a number of small tools, the sets required depending on the number of employees in the shop. These tools include rollers, concave, and flat; stitchers, smooth, and corrugated; rubber knives; fabric-cutting knives; long-bladed shears; awls, pliers, fabric hooks, etc. Other miscellaneous equipment includes brushes for casing or tube roughening, tread gauges, tube-splicing mandrels, inside casing forms, clamps, buffers, etc.

CURING

49. Too much care cannot be taken in the actual curing of a repair, as this is probably the most important step in the entire vulcanizing process. If the casing is cured too long, the rubber becomes hard and loses its elasticity, and if the curing is not carried on long enough, the tire is soft, and the repair is worthless. The length of time required depends on a number of things, such as the size of the tire, the nature of the injury, and the kind and thickness of the repair stock used. Until the operator has become familiar with the correct curing time for different materials, or has had sufficient experience to be able to judge the condition of the cure, it is a good plan to vulcanize a small experimental piece, before trusting the repair to the vulcanizing machine. A strip of properly vulcanized rubber will recover to almost its original length after having been stretched. If it is hard or stiff, it is over vulcanized, and if soft and inelastic, is under cured.

No stated time can be given for all repairs, but the time for tubes usually ranges from 5 to 8 minutes at 60 pounds pressure, to 6 to 12 minutes at 40 pounds pressure; for casing repairs, 30 to 60 minutes at 40 to 50 pounds pressure; and for retreading, 40 to 50 minutes at 40 pounds pressure and 15 to 20 minutes must be added to the curing time where a tread pad is used to preserve the pattern.

50. It is very important to know the degrees of temperature in relation to the pounds of steam pressure, and Table II, compiled by The Goodyear Tire and Rubber Company, can safely be followed in most cases. In extremely high altitudes, corrections will have to be made with the assistance of a thermometer, so that correct temperatures with the designated steam pressures will be obtained. To obtain the same steam temperature as at sea level, the gauge pressure will have to be ½ pound higher for each 1,000 feet of altitude above sea level. A gauge reading 40 pounds at sea level would read 42.5 pounds at 5,000 feet altitude in order to give the same internal pressure and temperature.

TABLE II

TEMPERATURES CORRESPONDING TO GIVEN PRESSURES

Temperature Degrees F.	Steam Pressure Pounds per Square Inch	Temperature Degrees F.	Steam Pressure Pounds per Square Inch
227.2	5	280.6	35
239.4	10	286.7	40
249.8	15	292.4	45
258.8	20	297.7	50
266.8	25	302.6	55
274.0	30	307.2	60

PORTABLE VULCANIZERS

51. Purpose.—Portable vulcanizers are small vulcanizing devices designed primarily for the use of the motorist in making minor repairs on the road or in the home garage, and in most cases are not intended for tire repair shops where very much vulcanizing work is carried on. The use of portable vulcanizers is best limited to emergency repairs, as considerable expense is often saved by sealing small casing cuts and breaks before dirt or moisture gets into them. When any extensive repair work is required, it is always better to take the tire to a regular vulcanizing station in order to insure that the injury will receive the attention that it really needs.

52. Electric Vulcanizers.—A popular form of portable vulcanizer is the electric vulcanizer, an example of which is the Shaler, type A, shown in Fig. 38. This device is shown clamped in place on the tube, in which a puncture repair is being vulcanized. The hole must be previously prepared for vulcanization as described in Art. 2 in connection with inner tube repairs. Either direct or alternating current can be used,

and the heat is evenly distributed to all parts of the repair, the temperature being automatically controlled by a thermostat, which closes or opens the circuit when the temperature in the vulcanizer rises above or falls below the required temperature.

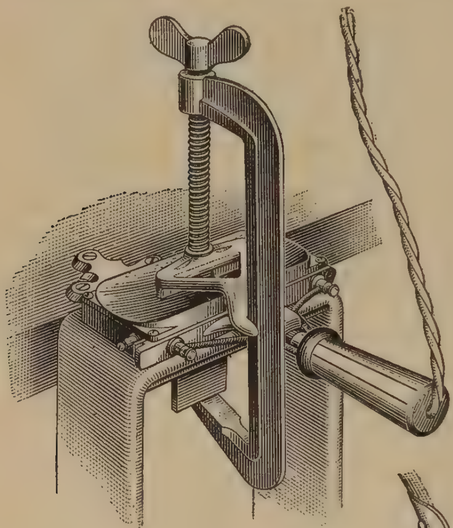


Fig. 38

The vulcanizer shown is made with one side flat and the other side concave. The flat side is used for inner tubes, and the concave side for casing repairs. It will fit tires of different sizes and can be used on casing while fully inflated on the rim or wheel. It is well when using this apparatus to follow the instructions of the maker carefully.

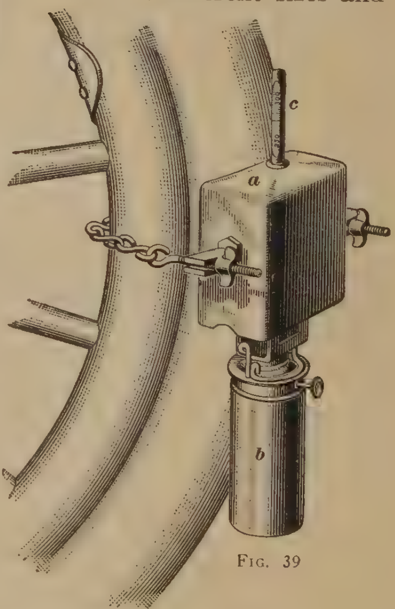


Fig. 39

53. Steam Vulcanizer. Small steam-heated portable vulcanizers are sometimes used in the same manner as portable electric vulcanizers for making small repairs on the road or in the garage. The steam is generated by means of a gasoline, or alcohol, lamp. Such a portable vulcanizer is shown in Fig. 39 clamped to a tire casing in the proper position for use. The

body *a* of the vulcanizer contains water which is heated by the alcohol lamp *b*. A thermometer *c*, fixed in the body of the instrument, indicates the temperature of the steam. The surface of the vulcanizer that is to be used in vulcanizing tire casings is concave while the opposite surface, or the one to be used on inner tubes, is flat.

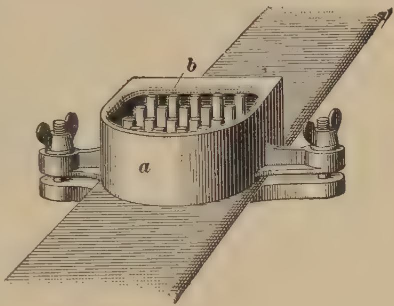


FIG. 40

54. Gasoline Vulcanizer. The Adamson vulcanizer, which is of the gasoline-heated type, is shown in Fig. 40. When an inner tube is to be vulcanized, the vulcanizer is laid flat as shown, gasoline is poured into the body *a* and lighted, and the vulcanizing process begins. In vulcanizing a casing, the vulcanizer is clamped to the casing in a vertical position with the cup *b* at the bottom. The gasoline is then poured into the cup and lighted. The amount of gasoline to be poured into the cup determines the length of time that the vulcanizing process will continue, so care must be taken to follow the maker's instructions in this respect, when using the device shown.

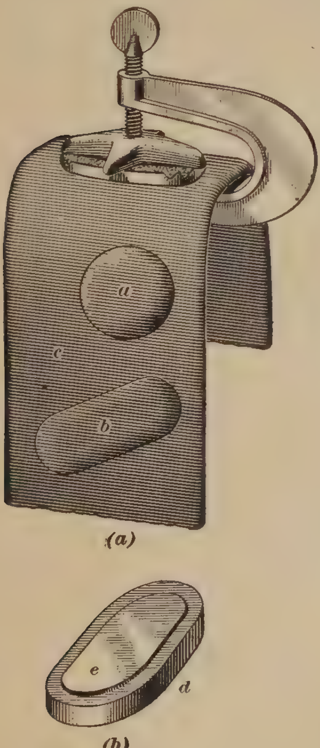


FIG. 41

55. Chemical Vulcanizer. A very handy and simple inner-tube vulcanizer is the Shaler Type M, shown in Fig. 41 (*a*). The important feature of this vulcanizer is the combined patch-

and-heat unit, which is shown in (*b*). The correct amount of a non-flaming chemical fuel is encased in the metal pan *d*, Fig. 41 (*b*), and a patch of raw rubber *e* covered by a linen protector, is attached to the vulcanizing surface. These patching units are supplied in round shapes for punctures and oblong shapes for cuts.

To vulcanize a repair, the linen cover is removed from the rubber surface, the unit is placed over the injury, the vulcanizer clamp is used to press the unit firmly in place, and the fuel is ignited. In 5 minutes the repair is finished. Heat is applied to the patch only, and the patch is moulded under pressure so that its edges are flush with the tube, leaving no chance for it to tear loose without tearing the tube itself.

The method of applying the vulcanizer is shown very clearly in Fig. 41 (*a*), and at *a* and *b* are shown patches already cured to the tube *c*.

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